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A STUDY OF PORT SAFETY FIREFIGHTING REQUIREMENTS.(U)

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A comparable fire in another port was the explosion-fire of the M/T Elias on April 9, 1974. The explosions and fire occurred while the last cargo was being stripped from the tanks. The Elias, like the Sansinea, had been completely refueled with fuel oil and diesel oil and the bunker barge lay alongside. Both ships had loaded ship's stores. Except for water temperature, environmental conditions were not significantly different: weak currents and light winds tended to move spilled oil on the water rather than directly to shore (at the Sansinea wind and current were opposed). Major hull peel-down on both ships was on the waterside rather than shoreside. The Elias situation was worsened because prevailing oil drift was out from rather than parallel to the ship and because a portion of the wind component blew smoke and flame indirectly towards a tanker starting to unload Venezuelan crude while moored bow to bow with the Elias with only 100 feet separation. Both fires caused serious problems of access and water supply. At the Sansinea land companies hand-laid almost 700 feet of hose. At the Elias, the nearest undamaged hydrant was three-quarters of a mile away, so land companies were supplied by two fireboats. The third fireboat directed master streams on the fire.

The most active firefighting response at each fire was as follows:

	Sansinea	Elias
Pumpers	7	16
Ladder	in task forces	7
Task forces	5	n/a
Municipal fireboats	5	3
USCG cutters	3 (82-ft)	2 (65-ft; 50-ft)
USCG UTB	4	5
Navy tugs	-0-	2 YTB
Commercial tugs	-0-	3+
Firefighters*	240	175

*Firefighter totals include all who responded. All did not work the fire, and all were not present at one time.

It can be seen from the tabulation that roughly equivalent responses occurred at both fires, both of land and waterborne forces. Response of land companies at the Sansinea might seem slightly larger, but part of that force was diverted to a nearby boat works. At the Elias, two commercial tugs were engaged in moving the other tanker. Boats at both fires participated in search and rescue. The Elias fire was essentially out in about five and one-half hours; the Sansinea fire was out in slightly over three hours, except for localized fires from severed pipelines.

Catastrophic: Fires categorized as catastrophic are those of such severity that a maximum response is necessary to contain the fire or to prevent continuing external spread

of damage. Regardless of size of response that can be assembled, these fires are unlikely to be controlled or extinguished until the majority of flammable or combustible materials have burned. Typical fires which are or could easily become catastrophic include ship fires in which all cabin space is burning, with fire on other decks and fire progressing through overheads and ventilation spaces; extensive flaming fire in a large, deep hold or hold containing flammable, explosive, or hazardous liquid materials, or small quantities of high explosives; fire in approximately half the deck-loaded containers on a loaded container-ship; severe engine room explosion with extensive spill fire and fire progressing to other spaces; collision rupture of two or more full cargo tanks carrying light crudes or refined engine fuels; rupture and fire in one liquefied flammable gas cargo tank; explosion of two or more large cargo tanks with fire in other breached tanks containing flammable cargo; explosion or fire involving six or more cargo tanks in a "drugstore" tanker configuration; fire from a single breached cargo tank containing chemicals which produce toxic combustion products (e.g., acetone cyanohydrin -- hydrogen cyanide; benzoyl chloride -- phosgene).

It should be noted that these categorizations of fire sizes are related in some degree to their potential for external damage. Thus a catastrophic fire for purposes of

this discussion is significantly smaller than the Texas City disaster. The collision-fire of the LPG tanker Yuyo Maru No. 10 and the Pacific Ares in Tokyo Bay in November, 1974, would be categorized as a catastrophic fire because it was a large, difficult fire and because the drifting Yuyo Maru was a threat to heavily populated areas and other shipping. The fact that the LPG cargo tanks never failed does not discount the necessity of assembling a significant response force to ensure a limit on the hazard from the ship.

The collision of the SS CV Sea Witch with the tanker SS Esso Brussels on June 2, 1973, produced an enormous fire extending 200 yards beyond the immediate perimeter of the two locked-together, drifting ships. The burning vessels drifted with a 2.5-knot current dragging the port anchor of the Esso Brussels, under the Verrazano Narrows Bridge at midchannel, and eventually grounded in Gravesend Bay. The vessels remained locked together until separated six hours after impact. Firefighting was by New York Fire Department fireboats, Coast Guard tugs and UTB's and many commercial tugs. Although the tank fires on the Esso Brussels were extinguished by the fireboats, the superstructure burned out. The Sea Witch containers on deck and in the hold burned for two weeks.

The collision of the SS Edgar M. Queeny with the S/T Corinthos on January 31, 1975, created an initial, severe explosion, followed about 30 seconds later by a second, more

severe explosion, which sent flames, debris, and a 100-ton section of the tanktop of Corinthos' cargo tank 3(s) onto the Queeny. The almost immediate spill of light crude oil from the Corinthos very quickly spread over the foredeck of the Queeny and over the water on both sides of the Corinthos. Within two or three minutes, almost the entire length of the Corinthos on the port (struck) side was in flames from the fire on the water and on the ship. Large fires from the Corinthos cargo, mooring lines, and other combustibles burned on the foredeck of the Queeny. The Queeny managed to back away after about eight minutes and proceeded downriver to anchorage about 1700 yards from the burning Corinthos. In the half-hour required for this maneuver, the crew of the Queeny successfully controlled the fire on the ship using foam from deck monitors. The mooring line on the forecastle was extinguished with foam from a hose nozzle.

The fire from the Corinthos in its immediate vicinity was for several hours significantly larger than the ship's 100-foot by 725-foot perimeter. In addition, very large patches of burning oil moved along and almost across the mile-wide river. At least one patch of burning oil on the river two miles away set fire to the entire 200-foot length and the superstructure of a decommissioned destroyer. Other docks and a small boat basin were threatened by burning oil on the river. Warehouses, product-handling

buildings, large storage tanks, and large diameter piping to the dock and along the bulkhead of the terminal facility had to be protected from the burning oil which ringed the dock and approaches and came near the bulkhead. Some equipment was assigned firewatch at nearby residential and other waterfront buildings. The widespread fire condition lasted about 4 hours and abated for about seven hours until a large spill from the ship occurred. The fire then burned back to the ship until another large flare-up ten hours later. The third large flare-up lasted about two hours. The fire then remained in the vicinity of the ship for 36 hours, at which time most of the remaining land companies withdrew.

The principal land company response consisted of four 1000-gpm pumpers, one 750-gpm pumper, one ladder company for ladder pipe operation, one aerialscope, and one squirt company. Two additional pumpers and a fireboat were employed for foam operations about eighteen hours after the collision. One other pumper was on standby at a distant hydrant in case relay was required. Water was supplied from one municipal hydrant, the terminal facility's 8- and 10-inch fire mains, and at high tide, by suction from the river. In all, 90 pieces of land equipment (including ambulances) were reported used in the 61 hours.

The major waterborne response consisted of two large municipal fireboats, three Navy firefighting tugs (2-YTM, 1-YTB), two large oil company firefighting tugs, one Army LT

tug, seven or more commercial tugs, and three small launches. Coast Guard response included one large buoy tender, a 65-foot tug, a 46-foot buoy boat, and two 40-foot and one 30-foot UTB's.

The number of active firefighting units reported at any one time at the *Corinthos* fire did not appear significantly larger than the response at the *Elias* fire. However, the available reports do not present information on the maximum equipment in use at any one time, but rather on the total which responded, whether used or not. It appears likely that the maximum waterborne response was increased by perhaps two large tugs providing 750 to 1000 gpm additional capacity. However, at the *Corinthos*, operations were spread over a larger distance, and much more boat time was used for herding oil or extinguishing fires on the water. That is a difference which characterizes the two different categories of fire: the *Corinthos* operation for the first ten or twelve hours concentrated on limiting the spread of damage, since there was no chance of extinguishing the ship fire. At the *Elias*, operations were more directly connected with extinguishing the more limited area of fire.

COMMENTS ON STATE OF THE ART AND PROBLEM AREAS

The project which is the subject of this report was initiated with the assumption that considerable detail of cases of Coast Guard and other agency marine and waterfront firefighting efforts should be a matter of record, although those details might be located in several different report sources. Given the details, it was assumed that certain levels or classes of fires could be identified which had been responsive to given levels or classes of attack. The quantifiable difference sought was that between the classes of fires which occurred and the classes of attack Coast Guard units could reasonably be expected to mount. Where responses are limited, this difference is the crux of the sizeup task.

A great deal of time was spent in reviewing various levels of reports, ranging from formal published reports of marine boards of investigation and National Transportation Safety Board reports, incident reports, situation reports, COTP base radio logs for specific incidents, OSC reports, published accounts of major fires in journals and other forms, and in two instances, letter-type informal information reports on certain aspects of firefighting. This information (or the lack of it) was supplemented by discussion with some participants at selected fires.

These resources did not provide adequate detail to develop the desired generalizations. In most cases, details about the firefighting were limited to a list of the agencies responding and times at which the event began and ended. Some reports included incomplete detail about equipment and manpower used but no information about how they were used. Brief descriptions of the waterborne forces and how they were used are generally somewhat incoherent and probably incomplete as to participating vessels. At large fires, radio logs suggest that the reporting vessels cannot see or are too busy to observe all other vessels on scene. Although there is usually an effort to report status changes to the base, the reports are on fire size, fire spread, and explosion. In a case where, for example, two large municipal fireboats, two Navy firefighting tugs, one large commercial tug with firefighting capability, two 40-foot utility boats, one 31-foot boat, two small Coast Guard tug-type buoy tenders, one 85-foot buoy tender, and two or three small commercial tugs are all on scene at one time, neither radio logs nor reports provide any information about what they are all doing at any one time.

Very large, near catastrophic fires--the Elias, the Sansinea, the Corinthos, the Keytrader, the Baune, and the Yuyo Maru,--are very rare events. Extremely large shoreside facility fires share an almost equal rarity. In this context, rarity is in reference to a 20-year career of one

individual firefighter or Coast Guardsman. Although there are no statistical data to support the generalization, the relatively small number of such fires in the United States in the last fifty years allows the reasonable inference that very few firefighters or Coast Guardsmen ever see such fires, and fewer yet participate in fighting them. Consequently, the fairly weak oral tradition about firefighting methods used, successfully or unsuccessfully, is rapidly dissipated by time, and even when fresh, is limited in dispersion. As a result, a real methodology for combatting very large ship fires has never existed. The "knowledgeable old chief with 30-years' firefighting experience," whether a CPO or a fire chief, may have fought a few ship fires, a very few large ship fires, and at most, one near-catastrophic fire. So although the old chief's experience is undeniably useful and usually effective, it is not his firefighting experience that is paying off. The results probably come from general skills of organizing and directing actions and from habits of scrounging and jury-rigging.

The principal problem at a very large ship fire is, "What can you do with a boat to combat the fire, and how do you do it?" The problem appears to be one quite different from firefighting when boarding the burning vessel is possible. Since successful control of shipboard fires is more likely if the vessel can be boarded, strategy and tactics designed to effect boarding would, if possible, be

quite useful. Although a few instances of such a sequence have occurred, usually at fires of lesser magnitude (small or moderate) such success is infrequent and probably represents the effect of confluence of chances, rather than of correct planning.

Since no useful published guidelines were discovered, particularly of a type that would apply to the types of operations Coast Guard units might face alone, it will probably be necessary to continue to rely on the judgment and resourcefulness that has served well in the past. That method, however, lends no comfort to the on-scene commander or on-scene coordinators.

This portion of the report discusses some of the kinds of problems, both organizational and physical, that have occurred at ship and facility fires in the United States. These are essentially problems which were not or could not be foreseen. This section is about kinds of problems that must be solved <u>after</u> they have occurred. As far as we could determine, the response which was organized for each of these fires was not a planned response, but a process of adding elements from very informal mutual aid relationships. It should also be kept in mind that at some of these fires, other emergency responses had to be organized, notably search and rescue, medical resources, and pollution control. In some cases, individuals engaged in planning the firefighting response and countering the

problems described here were to some degree involved in some aspect of the other responses.

Availability of General Guidelines for Initial Decisions

Magnitude of and threat posed by the fire, in firefighting jargon, is the problem of "initial sizeup." For shoreside facility fires limited essentially to Class A combustibles, the practice of sizeup is no different from that employed for any similar structural fire in a different location, and consists of estimating the building volume or floor plan area involved in fire, the progress the fire has made within the volume or area, a resultant estimate of the number of attack points, and the water flow desired. Since the most effective attack on such facility fires can be provided by land-based attack, the major responsibility will rest with local fire department land companies. Generally, either volunteer or paid departments can perform competent sizeup and mount an adequate response. In a few instances, the cajor fire front has been at the waterside and has developed in such fashion that land companies could not gain direct access to the principal fire. In most of those instances that have come to our notice, the fire was in a city with municipal fireboats which either managed to achieve a controlled-burning situation or were able to clear a path for land-based access. In a few instances, Coast Guard boats and commercial tugs have been the only resources available to respond from the waterside. In most instances

involving well-developed fires, the Coast Guard boats achieve only a minimal degree of control. Usually substantial portions of the facility burn. Fortunately, where "Class A" shoreside facilities are large enough to create fires which would constitute a severe threat to other significant facilities, they are usually in municipalities with the resources to contain the fires and limit their spread. What makes fires in wooden piers, wharves, and storage buildings problematical is the combination of a large quantity of usually very dry, sometimes creosoted, fuel and a typical structural design that enhances burning, frequently made worse by quantities of stacked combustible and flammable packaged cargo.

Terminal facilities handling flammable liquid bulk cargoes and a few types of dry bulk materials such as grain or coal pose a different set of problems because of the possibility of explosion fires and because of the potential for rapid fire spread from liquid spills to undiked areas and to water surfaces. A dry bulk facility explosion and fire may be a more complicated sizeup task due to some fire spread, access blocked by debris, damaged water supply, and a possible need for rescue activity during firefighting. However, again the major firefighting effort will be by land companies using only water appliances, and since any firespread is likely to be limited, response time of

adequate resources to control or extinguish the fire is not critical (except for rescue and for limiting economic loss).

Fires and explosions at bulk flammable liquid facilities are more difficult to deal with because of the potential for fire spread leading to more spills and fires or explosions; because of the possible need for marine units because access cannot be gained by land or because of ship fire or fire on a waterway; because of potential toxic vapor or smoke hazards; and because agents other than water may be required to extinguish or even control the fires. Of the problems mentioned, the one most likely to affect Coast Guard response is the access problem, since many bulk flammable liquid marine terminals are within jurisdiction of municipalities which lack waterborne firefighting capability and are frequently so distant from cities with fireboats that any waterborne response is from the Coast Guard, other federal agencies, or commercial sources.

The treacherous nature of the access problem was demonstrated at the Corinthos fire at Marcus Hook, Pennsylvania. Access to the dock adjacent to the burning vessel was blocked by a "15-foot high" mass of debris from a destroyed corrugated steel warehouse and its contents of drums of diethanolamine. After several hours of cooling the debris, hose lines were advanced over the debris. Fire-fighting had been going on for 20 hours. About 2 hours later, while about 30 volunteer fire fighters were on the

dock, a large flare-up occurred, ringing the dock and a Philadelphia fireboat supplying foam lines to the dock. Seven men were forced to jump to the deck of the waiting and endangered fireboat. The other 23 volunteers managed to flee over the debris to the connecting pier.

That the Corinthos example of problems of access is not an isolated case where explosion/fire occurs at dockside is demonstrated by the Sansinea and Elias incidents. Firefighting at the Sansinea was hampered by wreckage from the destroyed vessel, while at the Elias, the combination of a very narrow approach to the dock, explosion damage to firewater mains and hydrants, and low water made water supply by fireboat a necessity and increased the importance of having waterborne firefighting capability available.

The problem of fire spread on the water surface endangering other shipping or facilities occurred at the three fires mentioned. At the Corinthos fire, shoreside fires were ignited by burning oil patches on the river, in one case in a destroyer being salvaged at Chester, PA, over a mile from the burning tanker. Again, such incidents almost require Coast Guard intervention, even when large fireboats are available, simply because a number of boats may be needed to control the floating fires and fires they ignite. In more remote locations, both burning, floating patches of oil and burning, drifting barges have threatened other vessels and facilities. A relatively unusual case

dealt with by the COTP St. Louis, MO, occurred with an explosion of an unmanned tank barge at La Grange, MO. Spilled burning cargo drifted downstream around barges at a grain elevator. The tank barge was subsequently set adrift, struck and sank the floating barge terminal where it had been unloading, and drifted down upon the barges at the elevator, spilling burning cargo on their decks and breaking their moorings. At this time, four barges and a towboat were adrift and afire, a floating terminal was sunk, associated terminal facilities were afire, and a grain elevator was afire. The burning tank barge lodged at a railroad bridge upstream from Quincy, IL. Four hours after the initial explosion, the first Coast Guard team arrived by auto. Seven additional personnel were dispatched by truck from St. Louis three hours later. Thirteen hours after the initial explosion, eight Coast Guard and 6 firemen attacked the fire on the tank barge using six P-60 pumps and foam transported on a borrowed barge pushed by a commercial towboat. The fire was extinguished with foam after about an hour. The first Coast Guard boat arrived about fifteen minutes later, fourteen and one-half hours after the initial explosion.

In each of the cases just mentioned, there were significant and understandable problems with the initial sizeup. The Chief of the Marcus Hook Fire Department realized that the Corinthos incident was a fire of enormous

proportions in the immediate area of the ship and dock. He immediately called in considerable assistance. He was not aware, apparently, that other fires were on the water and along the water's edge until he sought assistance from Chester, PA, where the department was already engaged in fighting the destroyer fire. Similarly, probably because of the magnitude of the major fire, the Queeny was unnoticed by shoreside forces and apparently forgotten for a considerable time by responding boats. Again, the neglect was understandable since the Queeny never requested assistance.

At the Elias fire, initial response expected the availability of the installed fire water system, since draft could not be taken from the river at this location and the nearest alternative source was approximately 3/4 mile distant.

The barge fire was complicated by series of changing conditions: initially the fire was limited to the barge and its spillage on the terminal barge and towboat; additional spillage and sinking of the floating terminal occurred when the tank barge was cut loose; after the tank barge drifted against the barges at the elevator, two more barges and the elevator were afire. The most serious problem for which there was no immediate solution occurred when the tank barge fetched up at the railroad bridge, a potential threat to the town downstream. The barge was accessible only by water, but neither boats nor suitable appliances for use on a boat

or barge were available. Fortunately, conditions did not deteriorate before a makeshift response had been assembled and was ready to debark.

In summary, within municipalities, fire sizeup and the desirable response level to fires originating at a facility are subjects which appear to be ruled by experience and to a degree, alarm response policies of municipal departments. Where resources are available, the usual practice seems to be for first-in units to issue consecutive alarms to achieve essentially overwhelming response. When the fire is of catastrophic size, the response usually includes all locally available resources with additional aid from neighboring cities to go on line, provide reserves, and in some case, man stations which have been emptied by the emergency.

Availability of Equipment and Agents

The question of adequacy of supplies and agents for control of waterfront and shipboard fires is more important for large, extensively developed ports than for general waterways at large. Fires which occur on waterways or offshore are necessarily more important as a subject of search and rescue, and of necessity, loss of a vessel or the occurrence of an obstruction to navigation may be unavoidable. Complete, long term blockage of navigation on important waterways would appear, from a commonsense evaluation, quite unlikely. In most cases, vessel size and

waterway capacity appear linked in such fashion as to almost preclude the possibility that a single sunken vessel could entirely block traffic, or that the obstruction could not be removed, if necessary, in timely fashion. The most vulnerable part of any waterway would probably be lock facilities. The type of occurrence which could seriously affect locks would probably be explosion of a tanker transiting the lock. Long-term damage would be expected only in the case where the explosion damaged either gates or controls to the degree that the vessel could not be removed from the lock, or where the vessel exploded and immediately sank without excessive damage to the lock facility. The possibilities of either of these events should be too limited to merit active consideration.

Considered in the context just discussed, coupled with the stipulated relatively remote or more sparsely populated area and the lack of close-spaced, vital facilities through which fire might rapidly spread, the availability of agents and specialized equipment are of secondary importance. More planning and response activity is going to be geared to the major problems of being able to respond with any significant amount of equipment, depending principally on water for an agent, and of achieving a timely and adequate rescue operation. Beyond these immediate concerns, and evacuation if necessary, in remote areas the response effort will of necessity be directed to stabilizing

the emergency: that is, accepting that a fire of given proportions will exist for some period of time, but that it can be contained to some maximum size. Thus the order of precedence in assembling response forces will be (1) search and rescue; (2) evacuation, if necessary; (3) an initial firefighting level during which fire size might increase; (4) stabilizing capability; (5) reserve resources to maintain stable conditions over time; (6) obtain distant aid, equipment, and agent for extinguishment or reducing fire size.

Fire in active, large port areas should be manageable using only water to prevent spread of damage if adequate stocks of agents are not immediately available. Whether enough separate units to control all fires are available may vary with specific types of activity in the port. Generally, given time, as many land units as are necessary can be assembled. The availability of waterborne units is not at all predictable, even over a relatively long period of time. In the Philadelphia area, for example, there are at times at least three large oil company tugs and two or three large Navy tugs with significant firefighting capability available. Five or six of these tugs and two of Philadelphia's fireboats supplemented with any available commercial tugs and Coast Guard vessels provide enough capability for most emergencies, even though their response time is two to three hours. At times, however, all the oil

company tugs may be out of the port area (as far away as the Gulf ports) and the Navy may have only one tug in port which they are reluctant to commit very far from the Yard. Under similar circumstances, the Corinthos fire might have initiated far more serious consequences, because of inability to prevent spread of fire to fairly distant facilities. As a general judgment, based on communications in the Gloucester City Coast Guard Base radio log, the number of floating units was somewhat critical. In at least one instance, even a Philadelphia fireboat had to request the assistance of the second fireboat to control spreading oil fire. For some brief periods, the radio transmissions seem to indicate that the available waterborne resources were on the edge of being inadequate.

In general, study of accident and incident reports and discussions with COTP personnel at various levels and in various ports have not indicated that either major specialized equipment item or agent availability was a frequent problem. In a few instances, boats with even limited firefighting capability were not available. Ordinary fire department pumpers have been loaded on barges and used to fight fires along the Mississippi. A barge with a small derrick was used as a firefighting platform on one occasion. In September, 1974, a cotton fire was discovered in a hold of the Oriental Musician at Galveston, Texas. The hold had been flooded with carbon dioxide, but a high capacity pump

was desired before the hold was opened. In this case, the pump was obtained from Texas City in about three hours. In other major ports, such equipment might be less easily obtained.

Smaller items of equipment were mentioned somewhat more frequently, particularly by Coast Guard personnel, and particularly the men on the boats. Specific items mentioned at Philadelphia and New Orleans were not enough OBA's (oxygen breathing apparatus) or canisters, shortage of nozzles and connectors, lack of demountable monitors on some boats, and a question whether Nomex® standard turnout coats and boots might be better than standard issue clothing for cold weather firefighting. One item mentioned was lack of proper hoselengths to couple a demountable monitor to the pump output: only 50-ft lengths were available where 20- to 25-foot lengths were needed, so the excess hose has to be strung out around the stern and over the deck, creating clutter to stumble over.

Although it was not mentioned specifically as a problem, we noted in radio logs a number of instances of portable pumps, particularly the P-250, becoming inoperative. Reasons for or severity of the pump failure was rarely indicated. Although these are portable pumps not designed for long, continuous operation, dependability for eight to twelve or even thirty-six hours of continuous operation does not seem like an excessive goal. An analysis

of the causes of these pumps becoming inoperative after four to six hours use might indicate a need for a change in maintenance procedures and increased running time at test periods.

The availability of large quantities of firefighting agents appears to be a problem only in moderately remote areas such as on stretches of inland waterways and possibly the far northwest. Around major ports, foam agents are either locally available or can be flown in by large aircraft. Handling can sometimes present a problem. At the Corinthos fire, for example, foam agent was transported by police-escorted trucks from a factory warehouse to an adjacent pier, a 30-minute trip. Six hundred 5-gallon cans were then hand-passed by a 100-man chain of firemen to waiting Coast Guard boats, which then took the foam to fireboats and tugs at the fire scene. Agent for use by land companies at the Corinthos fire was mostly brought in 55-gallon drums, intended to be handled by fork lift. One pumper's installed proportioning unit was inoperative, so firemen had to manhandle the drums into position for use with an eductor. The problem with agents, therefore, is not the supply but the time required to move it, how to handle it, and more critically, probably, how it is to be paid for. With local non-commercial sources, such as local or federal agencies, airports, oil or chemical companies, payment seems to be a problem of secondary importance.

Most of the previous discussion of firefighting agent availability is most pertinent to low expansion foams. The only agents which are likely to be useful or most needed are foam agents and inerting gases. In the large port areas where fairly large quantities of foam agent might be needed, fairly large stocks are usually available through distributors or factory warehouses. These supplies are maintained for support of the industries serviced by the terminals and ships which cause the risk. Other sources of foam agents are the oil and petrochemical industries, which would usually stock from 500 to 5,000 gallons of agent; municipal fire departments serving large airports; naval bases; and active USAF air bases.

Inerting gases, such as liquid nitrogen or carbon dioxide, in relatively large quantities may not be quite as readily available, because of plant location and the requirement for specialized transportation. Some manufacturers of these gases habitually require at least 24 hours notice before delivery. Although there may be stationary sources (large tanks) of the desired gas at soft-drink bottling plants and other, heavier industrial plants, the need for specialized transportation limits the possibility of using these sources. Frequently, only the major supplier has the necessary tank trucks, and they will not be available for such emergency use.

Other types of agents are unlikely to be used in very large quantities, either because of cost (e.g., Halons) or because they require special equipment to apply them (e.g., high-expansion foam, dry chemicals). Although any of the foam agent concentrates are acceptable and, for all practical purposes in massive use, interchangeable, for most purposes, a salt-water compatible AFFF foam agent would be the foam agent of choice. Some fires in some chemical cargoes may require specialized foam types such as an alcohol-compatible foam.

Coordination

Coordination of all firefighting units responding to a small emergency does not seem to be a significant problem except in those cases where timing becomes important. A typical occurrence under that circumstance might involve expenditure of all foam agent concentrate before additional supplies can arrive, resulting in loss of any headway gained against the fire. This can be a more critical problem at a small fire because of the possibility of the fire involving larger portions of the ship. Land based forces seem somewhat less susceptible to coordination problems even with moderate to large-scale fires. Fully satisfactory coordination between units attacking from both land and waterside rarely occurs, so that some percentage of the attack is inefficient and of low effectiveness. In a few instances, units have sought to perform functions contrary to those

desired by the persons nominally directing the event. In instances mentioned in discussion with participants, the disagreement seemed to be the result of impatience or the dissenting unit's doubt that the unit was needed or being effectively used. Usually the disagreement appeared to be a symptom of inadequate briefing by the persons in charge. Such cases are probably individual in nature, since most responding mutual aid or outside units immediately comply with instructions. Less cooperative units may require explanation of their expected role and the overall strategy. At small to large fires, this sort of problem is less likely to occur, probably because assisting units from nearby cities have a more long-standing and closer relationship with the home units; because the overall emergency is less complex; and because the smaller combined attack force will be immediately engaged in some direct action. Waterborne forces, which commonly may consist of a mix of federal, state, and local agency boats, commercial boats, and even private boats, were not mentioned as having similar coordination problems at small to large fires. Dissent probably was not noted because far less direction and communication is available or employed, tactics do not appear to be planned or systematically executed, and more frequently, private and commercial boats as well as some local agency boats simply leave without comment.

A problem that has been mentioned in some locations, particularly at small fires, is a facility guard's refusal to allow land companies to enter the facility. In at least one case, the gate guards did not believe a fire was in progress. There is little the facility can do about responding boats, although the attitude about boats from federal agencies is about the same: the uncooperative facilities consider their action unwanted interference.

The activities of other agencies with responsibilities unrelated to firefighting or search and rescue, including news media, were not mentioned as being noticeable at small to large fires. For fires in this size range, coordination of separate, unrelated activites is probably not necessary as long as control of activities near the fire is substantially maintained. Since these fire sizes usually are controlled within 24 to 36 hours, it is not necessary for unrelated activities to impinge on the firefighting. Consequently, major coordination efforts should focus on local and mutual aid firefighting units, the facility, police agencies to secure the general area and expedite movement of equipment and supplies, and if vessels are involved, the ship's agents.

At large to catastrophic-size fires, coordination becomes a significantly greater and more complex task. Even if no other interests or activities except police, firefighting, and search and rescue were involved, management of

the responding units to achieve an efficient attack or a long holding action (controlled fire) can be difficult.

The specific kinds of coordination problems that occur at catastrophic fires were not well documented in any cases examined in this study. In part, there was a tendency of individuals interviewed to neglect to mention problems, apparently to avoid the possibility of offending other groups who had responded to assist at the fire. Consequently, the problems which were identified usually came up in discussion only as a result of a chance comment or upon questioning about some peculiarity noticed in communications logs. A few such cases are discussed below.

1. At the <u>Corinthos</u> fire, the first alarm was from the Marcus Hook Police Department to the Delaware County Fireboard (the county-wide radio network). The Marcus Hook Fire Department called in a second alarm a few minutes later. About forty-five minutes later, the Marcus Hook Fire Department called the Delaware County Fireboard with a request for special equipment for use at the pier and warehouses (an aerialscope, squirt, and ladder truck). However, after the Delaware County Fire Marshal learned of the fire, calls for assistance began to emanate from two sources, the Chief of the Marcus Hook Fire Department and the County Fire Marshal. This resulted in some confusion about who was in charge. After some delay, this was worked out--more or less.

The Delaware County Fire Marshal worked on managing the staging area point, setting up rotating schedules for relief crews, and may have participated in discussions about strategy and obtaining supplies for foam agents. The Delaware County Fire Marshal at times may have acted as general spokesman, which created some ill will.

2. Some confusion and difficulty arose because intially, a staging area had not been set up. The problem was probably compounded by the County Fire Marshal calling in units not expected by the Marcus Hook Fire Department.

3. Communications between land and waterborne forces were not good. Communications between USCG vessels and fireboats were not handled well. For example, to report a flare-up and request land unit assistance, the Philadelphia fireboat called Philadelphia F. D., Philadelphia F. D. called Base Gloucester, Base called Marcus Hook F. D. Initial notification through Delaware County Disaster Control Center led to some confusion through actions of the County Fire Marshal and probably some voluntary response by units who were not specifically called for aid.

4. At the Sansinea fire, two sources stated that significant time, equipment, and agents were expended on fires in and around the inverted deck and deckhouse which was torn from the ship and landed on shore. These

commenters believed those resources had been wasted, and claimed that for nearly an hour, firemen did not realize the inverted deck structure was on shore, but instead believed they were attacking fire on the ship itself. We doubt the validity of the judgments implied by these comments. We believe the mistake may have occurred intially, but that in any case, access was so difficult because of debris that knocking down much of the fire on shore was necessary before lines could be advanced to the ship. Some resources may have been unnecessarily expended on fires from ruptured pipelines. However, the effort to control those fires was not a result of total confusion and general incompetence.

5. At the Corinthos fire, there was apparently a short-lived rumor that widespread sabotage might be taking place. The unease began with discovery that a fire was in progress at a destroyer three miles away. This apparently led to a brief fear that marine firefighting assistance would not be available if additional fires occurred at the Navy yard and other Philadelphia facilities. In this case, the rumor was brief and did not affect dispatch of assistance. Further, had assistance been delayed, the delay would have had little effect on firefighting, although it would have affected rescue and survival. Under other circumstances, such a rumor caused by the unexpected

distance of firespread could have a damaging effect by diverting or delaying needed resources.

Choice of Coordination, Control, or Command

Some general questions regarding practical matters which were considered in discussions with various port agencies and authorities and in other information-seeking activities can be summarized as, "How should a response be put together?" and "How can that quasi-organization be managed?" The most important single issue mentioned (or frequently only hinted at) in our judgment is the necessity of a single spokesman/authority. From a practical standpoint, achieving a specific focal authority becomes more difficult as the size of response and number of responding agencies increases. Similarly, from a practical standpoint, the need of a focal source becomes more important as the response becomes larger. While it is by no means necessary that all decisions be made by a single individual, all participants in the group doing the organizing and decision-making should defer to one spokesman--always.

A second issue that was mentioned appeared to be the result of some confusion about how to assume and use the necessary authority. While delegating some general task or objective appeared to be acceptable to non-local officials and their personnel, issuance of what was interpreted as a command or order was objectionable, particularly if it was for a specific tactical maneuver and included instruction

how rank and file personnel were to accomplish it. The generally stated objection to such perceived orders was that the order exposed men to risks that had not necessarily been evaluated by their own officers, and that this type of command was improper since it did not issue from intimate knowledge of strengths and weaknesses of the unit and its equipment. However, in the few specific instances of such "orders" described, the objections mentioned seemed irrelevant. The real objection seemed to be, "No outsider is going to tell me what to do with my men and my equipment."

"No outsider can tell me what to do" could easily become a major problem at any situation requiring what is essentially voluntary assistance from outside resources. The local authority appears to be as susceptible to this attitude as the outsiders. The "It's my crisis" attitude can lead to both rejection of advisory sources as well as the mistake of issuing orders instead of delegating tasks. Although in matters of apparent urgency direct orders may seem necessary and proper, that same urgency can contribute to argument about or rejection of the order. Therefore the focal authority must tread a very narrow line in directing operations, particularly if he and the outside group have had little or no joint or cooperative experience.

It is always simple to observe and comment on the general obstinancy of others to follow what we observe to be

necessary and reasonable advice. The comments here regarding coordination are for the purpose of pointing out that what may be perceived as obstinancy is in fact unstated or formal policy. Thus the behavior discussed is the stated, formal Coast Guard firefighting policy. While we know of no instance where a Coast Guard boat refused to take a specific action, it is possible, simply on the basis of policy. Consequently, any judgment about "obstinancy" should be tempered by realization that the behavior may be directed by other considerations.

The problems of coordinating, controlling, and directing operations could probably be reduced through training or familiarization from exercises based on fire disaster response plans. Such exercises should include more than exercise of communications and control networks, particularly if they were conducted no more frequently than annually. Because of costs, however, very successful efforts of this type are not likely to be instituted.

GENERAL USCG FIREFIGHTING CAPABILITIES

Because of the many generalized assignments which have been delegated to the U. S. Coast Guard, the observation of the moderately informed outsider is almost necessarily that miracles are being performed. Despite what appears to be, for the magnitude of the tasks, an underfunded, undermanned, underequipped, and overworked service, the Coast Guard has managed to achieve creditable, if not outstanding, results in all its tasks.

Because of its long and continuing dedication to safety of life at sea, and particularly the priority set for search and rescue, if a ship or port fire occurs within reach of a Coast Guard installation, the Coast Guard will respond. It is probably this tradition, coupled with a strict aversion to infringing on other jurisdictions, that creates a problem about what the Coast Guard should do at ship and waterfront fires. The basic problem is what should be done if the apparently responsible political or economic jurisdictional unit either cannot or will not provide for waterborne firefighting resources. It is perhaps not recognized that the general public has the notion that a ship fire in particular, and some waterfront facility fires, are the Coast Guard's problem. Small fire departments are especially and sincerely convinced that their responsibility ends at or behind the water's edge. Although they usually

do whatever they can with their available equipment, there remains a high expectation that the Coast Guard can and will relieve them of any problem beyond the water's edge. Large city fire departments have expressed similar beliefs about fires beyond their jurisdictional boundaries, even at fires to which they responded on a mutual aid or other basis. Even a Philadelphia fireboat commander, although expressing a permanent willingness to respond to fires anywhere on the Delaware and Schulkyll Rivers, commented that a ship fire outside Philadelphia proper was really and ultimately the Coast Guard's problem.

Policy Versus Practice

It is the stated policy of the U. S. Coast Guard by Commandant Instruction that "Coast Guard equipment and personnel, as may be available, may be used to assist in fighting marine and waterfront fires." The instruction recognizes some limitations of equipment and supplies in some areas, and specifies that personnel "shall not assume control of the overall firefighting efforts whenever local authorities are present."

A few studies have been made addressing the subject of Coast Guard firefighting. The degree to which capability was judged effective reflected how strictly the study or comment interpreted the Commandant's instruction. If the comment was based on observation of what in practice occurs, (frequently, what necessarily occurs), capability was judged

less effective. If it was assumed that the Coast Guard rarely needed to be the primary waterborne response, the capability was judged adequate within the guidelines.

One significant Coast Guard study of the problem was done in 1964-1965 by a study group headed by Captain Harry Morgan. The "Morgan Report" was based upon statistical studies, questionnaires to COTP's and District Commanders, visits to ports and discussions with port city fire departments, and some internal discussions bordering on engineering evaluations and feasibility investigations of equipment capability. This report identified the principal problems:

1) The frequency of waterfront and ship fires is so low that many municipalities will not provide waterborne firefighting capability.

2) The potential for large or disastrous marine fires, however rare, exists in areas remote from large cities which can afford waterborne firefighting capability.

3) In most ports and waterways, where waterborne firefighting capability does not exist, it will not be provided by either political or economic entities.

4) If a catastrophe occurs in areas where the Coast Guard operates but no local capability is available, the Coast Guard will be blamed.

5) Regardless of local firefighting capabilities, if available, the Coast Guard will always be involved in the firefighting.

6) Present firefighting capability of vessels in the Coast Guard fleet is minimal or less.

7) Ancillary supplies and personal protective equipment are not adequate in most areas.

8) Although some maritime changes through improved construction, more stringent regulation, and traffic control should reduce the incidence of fires, the changes are not likely to offset increased potential due to increasing traffic, new commodities, and larger vessels.

9) Improved firefighting equipment and more supplies should be made available. "Where firefighting capability is provided, it should be sufficient to be effective." Preferred minimum installed pump capability specified was 500 gpm at 150 psi for boats 65 foot and under, and 1000 gpm at 150 psi for boats over 65 foot. Installed foam tanks and proportioners and 200 feet of hose were recommended for all boats.

10) Areas mentioned as those needing more or improved Coast Guard firefighting capability were the inland waterways, the Mississippi, and the Second, Eighth, and Ninth Coast Guard Districts.

Most of the comments in the 1965 Morgan Report are relevant today, despite considerable changes in regulation and in operations activities and equipment improvements in commercial vessels and facilities.

In January 1974, Arthur D. Little, Inc., produced as Modification 15 of Contract DOT-CG-24-655A a restricted report which discussed Coast Guard firefighting capabilities. The limitations specified include an implied insufficient pump capacity, lack of space and weight-carrying ability, lack of elevation and deck space for firefighting activity, lack of cargo lifting gear to handle portable equipment, and limitations on amount of agents that can be carried. The problems of access for shipboard firefighting are also mentioned. Some comments are made on possible aircraft uses. Because the principal

object of that report was to develop a name-brand list of potentially useful equipment, options but no minimum capabilities are recommended. Similarly, no criteria are provided for selecting minimum capabilities.

In May, 1976, Commandant Instruction 11320.7 was issued. This Instruction is more broadly based than 11320.4 of 1966 and provides more detailed guidance. It continues to maintain essentially the "support if available" policy, although it expresses recognition that in some locations, the Coast Guard may be the only waterborne firefighting capability and may have to act as On-scene Coordinator for all organizations that respond.

The preceding discussion indicates that the problem of Coast Guard reluctance to assume a greater role in marine firefighting versus the practical necessity that it do so has been existent for years. Since shortly after the end of the Second World War, a widespread, moderate marine firefighting capability has not existed. The fairly large fleet of tugs and other vessels fitted for firefighting during that war apparently was fairly quickly retired without replacement. Of the existing fireboat fleet nationwide, the majority are 20 to 25 years old. Many have been removed from service because of high operating costs.

The position historically taken by the Coast Guard, i.e., that it should not be the primary marine firefighting agency, is a practical one, considering the equipment and

manpower available, and the many other services those resources must render. It also seems proper that local resources should provide for the safety of the local trade complex, the benefits of which are more immediate locally than to the nation at large.

A contrary but equally practical rationale for assessing current policy involves those regions where maritime activities are merely in transit but pose potentially severe threats to waterside communities. For these communities, local benefit is the same as the limited benefit to cities far inland, with the consequence that there is no income from the trade that creates the hazard. The second part of this rationale recognizes both the necessity and custom of Coast Guard participation in firefighting, or its role as sole source in remote locations.

Although the present policy on Coast Guard participation in firefighting is necessary as a means of reducing local inclinations to eliminate fireboats and marine firefighting activities because of costs, that policy alone may not prevent such actions. In addition, expansion of port facilities and growth of trade may extend in-port fire hazards, while local firefighting capability remains static or decreases. Consequently, it may become necessary for COTP's to establish local response capability levels, and to require adjustment of those levels in response to

port expansion, growth in traffic, or significant change in commodities moving in or out of the port. Under this alternative, threat of restriction of trade might be necessary. The judgment would have to be made whether the increased development and trade offset potential losses in port facilities and perhaps lives.

As another alternative, the present strategy for control of pollution of navigable waters might provide a model from which similar strategy for coping with waterfront and ship fires could be constructed. Under this strategy, response systems provided by commercial organizations are in place, and major costs are borne by the offender. Under such a system, local governmental units could choose and bid to provide the service. In an area like that from Philadelphia to Marcus Hook, PA, for example, where local governments are individually too small to maintain marine firefighting capability, a response system could be set up by a consortium of the small municipalities or by the county. The system could then be funded through taxation or bond issue, with substantial recovery of costs from response fees.

Specific requirements for a firefighting response capability certainly would be resisted as a requirement of extraordinary expense with low potential for use. However, systems for control of pollution in navigable streams are no more cost effective; the emergency rarely represents a

life-threat; and the pollutants generally constitute only a minimal threat to income resources. More significantly from the point of view of the COTP's, few if any pollutants could destroy or adversely affect significant operations in a port area, particularly to the degree of affecting national interests.

Returning again to effects of present policy, an apparent side effect may have been a tendency to limit firefighting capability to the degree that the Coast Guard and its own personnel suffer most. For most Coast Guard boats, present capability is just enough to get the boats into trouble. Although instructions to limit the hazard to crews would seem enough to counter the problem of limited capability, the instruction is probably only rarely useful, because the crews cannot gain enough firefighting experience to recognize the degree of risk involved. In the more problematic areas, where only Coast Guard boats and random commercial tugs are available to provide assistance to burning vessels, rescue may require the crew to take risks that they recognize as extraordinary. As has been discussed elsewhere in this report, even in remote areas, significant, "innocent," waterside facilities and other traffic can be severely threatened by burning vessels and shoreside fires. The presently limited firefighting capability of Coast Guard boats only compounds the already severe problem of long response distances. How close to futile the existing

capabilities are with long response time is illustrated by the generally recommended practices for municipal fireboat operations. Desirable response time for a fireboat is five to ten minutes from notification. The assumption is that response time will catch the fire in an incipient stage, and that the fireboat's 5000-gpm (or minimum 2500-gpm) flow rate will allow control of the fire. Compare a two-hour response time and attack with 250 gpm, or even 250 gpm augmented with a not always reliable 250-gpm portable pump. While it should not be expected that the Coast Guard should emulate municipal fireboat operations or provide equal equipment for the locations in which it operates, and particularly in remote regions, current equipment and response-time capability are of marginal or less value in many locations, even those where no other resource is available.

SOME FACTORS AFFECTING
FIREFIGHTING CAPABILITY

One of the subtasks under Phase I was to examine the question of firefighting capability of boats in the Coast Guard fleet. It was expected that the boats would fall into some recognizable classes, based mostly on pump capacity and pressure ratings, with adjustment for peculiarities of water connections between pump and nozzle or monitor, power source, crew size, and vessel size. These classes might then be rated against fire types expected, again assuming that there would be a limited range of fires to which Coast Guard boats responded. Actual information about fires the boats have fought does not exist except for scattered reports which contain little or no detail about the activities of the boats. Information obtained from reports and interviews indicate that the range of fire types and sizes is not limited and that the total "population" of fires is not amenable to categorization, other than assignment to a size class as discussed elsewhere in this report.

Classification of boat capability against even a single fire size is also virtually impossible because of the wide variation in the boats and their equipment.

The notion of firefighting capability is a purely artificial one. Under rigidly controlled conditions, an approach can be made to the concept the words "firefighting capability" attempt to convey. Under those conditions, relative differences can be observed in the response of a fire to different extinguishing methods, equipment, or agents. Removed from the test and experimental environment, fires and firefighting are only two more variables in a complex and entirely variable system.

"Firefighting capability" for the purpose of this report refers to some relative level of effect that probably would occur, assuming average condition of all variables. The general basis for the approximate effect is either calculated or a test result, modified by a judgmental factor to account for absence of "average" variable conditions in the method of calculation or affecting the test. Since water and foam agents are those most likely to be used, they are the only agents seriously considered. The effect of water is based on estimation of cooling value in its conversion to steam. The effects of foams are based on pool fire test results.

The generalization of overall capability is not based entirely on agent delivery rates, but includes indefinable elements of judgment such as effect of crew size or vessel size. Larger crew size is a positive element and usually implies a larger vessel. Larger vessels provide

more working space and agent storage space, offer a wider variety of heights above waterline, can carry more hose and remain longer on station. Conversely, larger vessel size may affect draft, limiting inshore movement, affects maneuverability for position, and limits speed of withdrawal (escape maneuver). Size generally enhances station keeping. Keeping these and, in fact, the multitude of other variables in mind, comments on capability are essentially judgmental. On balance, however, given the data which is the starting point, for the average incident, the estimate should not be excessively in error.

At the beginning of the project, there appeared to be a possibility of three or four levels of capability over the assortment of vessels mentioned in the tabulation. The largest vessels (378-foot, high-endurance cutters, for example) would in cases like fire at sea have the important characteristic of significantly greater seaworthiness, and with extra portable pumps, might be separately classed. At other types of fires in other locations, however, reports indicated much less utility of larger vessels. Consequently, the logical division of classes seemed to be into only two classes: those larger and those smaller than 80 feet in length (the new 32-foot port safety boat is separately considered).

It is necessary to keep in mind that the capability estimate is in relation to any marine or waterfront fire, not just the fires for which a boat might be ideally suited.

Water Systems for Firefighting

The principal system upon which all firefighting depends uses water as an agent. For any waterfront or waterborne firefighting capability, primary dependence is always upon the water systems, mostly because water is in unlimited supply, whereas no other agent could be carried and delivered in such vast quantities. Coast Guard boats also rely on water systems, but the capability of those systems varies.

Vessel sizes and equipment considered in making the capability estimates were tabulated in a report prepared for internal Coast Guard use by Arthur D. Little, Inc. (Table 1).

The design basis upon which some pump ratings were chosen would seem to be unfathomable. The most extreme example of peculiar pump choice occurs on the 110-ft WYTM "A" with its two, diesel powered, 1200-gpm pumps, each rated at only 75 psi. The lowest pressure installed pump is the 300 gpm, 50 psi pump used on the 327-ft, high-endurance cutter. The lowest capacity, installed pumps are 60-gpm, 100-psi pumps provided on various boats up to the 100-ft WLI.

The National Fire Protection Association "standard fire stream" is the 250-gpm flow from a 1 1/8-in nozzle tip on a 2 1/2-in handline at normal operating pressure at 150 psi. Nozzles for 1 1/2-in hose are normally designed to

TABLE 1. FIRE PUMPS ON SELECTED USCG VESSELS

Class	Fixed Pumps* Quantity	GPM	PSI	Drive
30 ft UT MKIII	1	60	100	Main Engine
40 ft UT MKVI	1	60	100	Stbd. Engine
41 ft UT**	1	250	100	Main Engine
44 ft MLB	1	120	100	Port Engine
45,46 BU, BUSL	---	---	---	---
65 ft WYTL	1	300	100	Main Engine
75 ft WLIC	1	60	100	Electric
	1	250	150	Diesel Engine
65 ft WLR	1	60	100	Electric
82 ft WPB	1	60	90	Electric
95 ft WPB	2	120	90	Electric
	1	275	90	Diesel Engine
100 ft WLI "B"	1	60	90	Electric
110 ft WYTM "A"***	2	1200	75	Diesel Engine
Class "B"	1	1200	75	Diesel Engine
157 ft WLM	1	250	120	Elect. 30 HP
180 ft WLB "A" "B" "C"	2	100	100	Electric
133 ft WLM	1	300	100	Electric
210 ft WMEC	2	250	125	Electric
GLACIER	2	750	100	Electric
	2	300	120	Electric
269 ft WAGB	1	400	120	Electric
	1	300	120	Electric

TABLE 1--CONTINUED.

Class	Fixed Pumps* Quantity	GPM	PSI	Drive
290 ft WAGB	2	300	120	Electric
	1	300	120	Electric
327 ft WHEC	2	120	125	Steam
	2	300	50	Electric
	1	350	150	Electric
378 ft WHEC	3	500	125	Electric

*P-250 (250 gpm) portable pumps are standard equipment on most USCG vessels.

**41 ft UT carries portable deballasting pumps (ADAPTS).

***WYTM vessels have two 3" monitors on board.

discharge about 100 gpm. Only the 75-ft WLIC, and the 327-ft WHEC, and the newer 32-ft port safety boat have installed pumps rated at the "standard" pressure. The 110-ft WYTM and the 32-ft boat are the only vessels smaller than the 210-ft medium-endurance cutter which can provide the "standard fire stream" flow. The smaller boats, even those with indicated ratings near the standard, probably do not achieve the expected pressure and flow at the nozzle, because the pump is driven by a propulsion engine (shared use), and because of suction lift, piping, and connection losses. The installed pumps are sometimes supplemented with the P-250 portable pump rated at 250 gpm at 100 psi, if available.

The range of effectiveness of a fire water nozzle is dependent on the "reach" and "loft" distances that a good fire stream can attain. A "good" fire stream is difficult to precisely determine (hence the scatter in available data), but is usually defined as the point at which the stream breaks into fine particles or separated water slugs. Both reach and loft are dependent upon the system conditions, particularly wind, nozzle size and type, and nozzle pressure. The stream integrity is not substantially reduced in winds up to about 5 mph, but from about 10 mph and higher, adverse winds seriously shorten the effective range.

There is an optimum pressure for each size and type orifice which will maximize the reach and loft capabilities of a nozzle. At low pressures, the nozzle cannot deliver the required flow quantities. At high pressure, the water stream is destroyed and spray or fog is created. Fog ranges seldom exceed 30 feet in effective range. The optimum pressure for a 1-inch orifice is about 100 psig; a 1 1/2-inch orifice about 150 psig; a 2-inch orifice about 200 psig; a 2 1/2-inch orifice about 250 psig; a 4-inch orifice about 300 psig; and a 6-inch orifice about 350+ psig.

There appears to be no correlation between nozzle efficiency (the ability to convert pressure into velocity) and the range of stream effectiveness.

Figure 1 presents a relationship between loft and reach for several different nozzles at their respective optimum pressures. This data was compiled from data furnished by Stang Hydronics. A review of other available data indicated that the reach and loft data are relatively dependent on manufacturers' definitions of "good" stream as well as the type of nozzle.

The effect of available pump performance therefore is upon projection of a solid stream and upon quality and distribution pattern of spray from fog nozzles. With the standard Coast Guard all-purpose nozzles, a solid stream is projected horizontally for 65 to 75 feet. Some standard fire hose nozzles and monitors may produce slightly greater

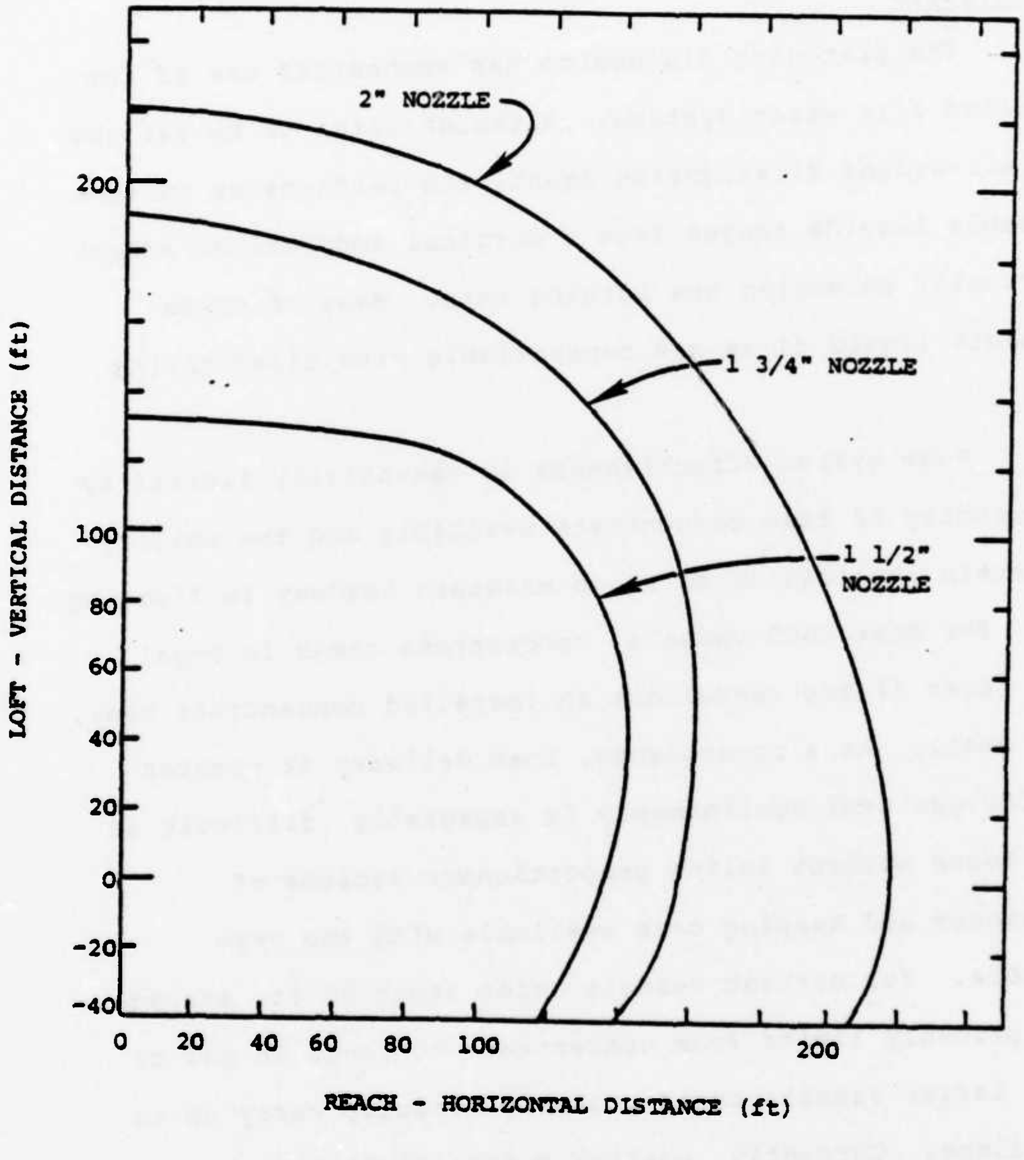

FIGURE 1. MAXIMUM RANGE OF WATER MONITOR NOZZLES.

range, up to 100 feet or 140 feet if pressure at the nozzle tip were 100 psi (Figure 1).

<u>Foam Systems</u>

The preceding discussion has emphasized use of the installed fire water systems. Although water is by far the best all-around firefighting agent, its performance on some flammable liquids ranges from a marginal suppression effect to actually enhancing the burning rate. Many of these flammable liquid fires are controllable with firefighting foams.

Foam system effectiveness is essentially limited by the quantity of foam concentrate available and the ability to sustain application so as to maintain headway in fighting fire. For most USCG vessels, concentrate comes in 5-gal cans. Even if the vessel has an installed concentrate tank, it is small. As a consequence, foam delivery at greater than 250 gpm semi-continuously is especially difficult on small boats without inline proportioners because of can-changes and keeping cans available with the crew available. For current vessels under about 80 ft, storage space probably limits foam concentrate to about 50 gal or less. Larger vessels could probably usefully carry up to 300 gallons. Currently, smaller boats (30-41 ft) may be carrying only 15-30 gal. For purposes of any first response call, originating from base, at least 30 gallons of extra concentrate should be loaded on deck, depending on available space.

For smaller boats, providing additional foam concentrate will improve first response foam capability, since the effectiveness of foam depends on quantity delivered rather than rate of delivery for any fire size a single small boat might hope to contain. The only practical difference of rate of delivery in this case is in extinguishment time for a given fire size.

The practical effect of these parameters is that for first response foam application, pumping capacity on the current generation of USCG boats in excess of about 250 gpm offers no particular advantage because the foam blanket normally will not degrade before all available foam concentrate is expanded. For very large fires, a higher application rate prevents loss of the blanket, but for fires this large, several boats and a continuing supply of foam concentrate should be available. The problem of hot-surface shrinkage of the blanket is probably not a significant one, because the majority of the surface area fire can be controlled and the fire can be approached for final extinguishment. The 250-gpm limit also appears to be a practical limit beause of the can-changing problem.

On any first-response, there might be an advantage in using foam on any class of fire unless there is imminent danger of a subsequent hydrocarbon spill and fire (e.g., wooden pier supporting transfer hoses). Although foam is not commonly used on Class A fires, one should get added

effectiveness from its water content due to retarded drainage from surfaces. For the smaller boats, this procedure might allow more rapid reduction of the fire size, to make it more manageable with the water systems.

That even small boats with pumping capacity of only 60-100 gpm can control fires which, though not large themselves, could spread or cause other failures and spills is illustrated in Figure 2. Figure 2 presents typical results of tests of the two types of foam agent likely to be available against pool fires from hydrocarbons like gasoline. The data represent the solution (foam agent plus water) flow rate necessary to control various fire sizes in 90 seconds. Even assuming effective delivery of only 25 percent of the flow rate, a small boat with nominal capacity of 100 gpm should control 250 ft^2 of fire area in 90 seconds with protein foam and 500 ft^2 with AFFF. Up to some significantly larger fire size, control should be maintained at the same rates (about 165 or 330 ft^2/min) as long as concentrate lasts. This estimate is for production of a single leading edge advancing along the pool, and might not hold true in the case of a large flaming pool where the foam blanket had to advance a 180 degree arc front against the flames.

Since the results presented in Figure 2 are not significantly different from results obtained in U. S. Navy tests on Av-gas fires at Miramar, CA, and Coast Guard deck

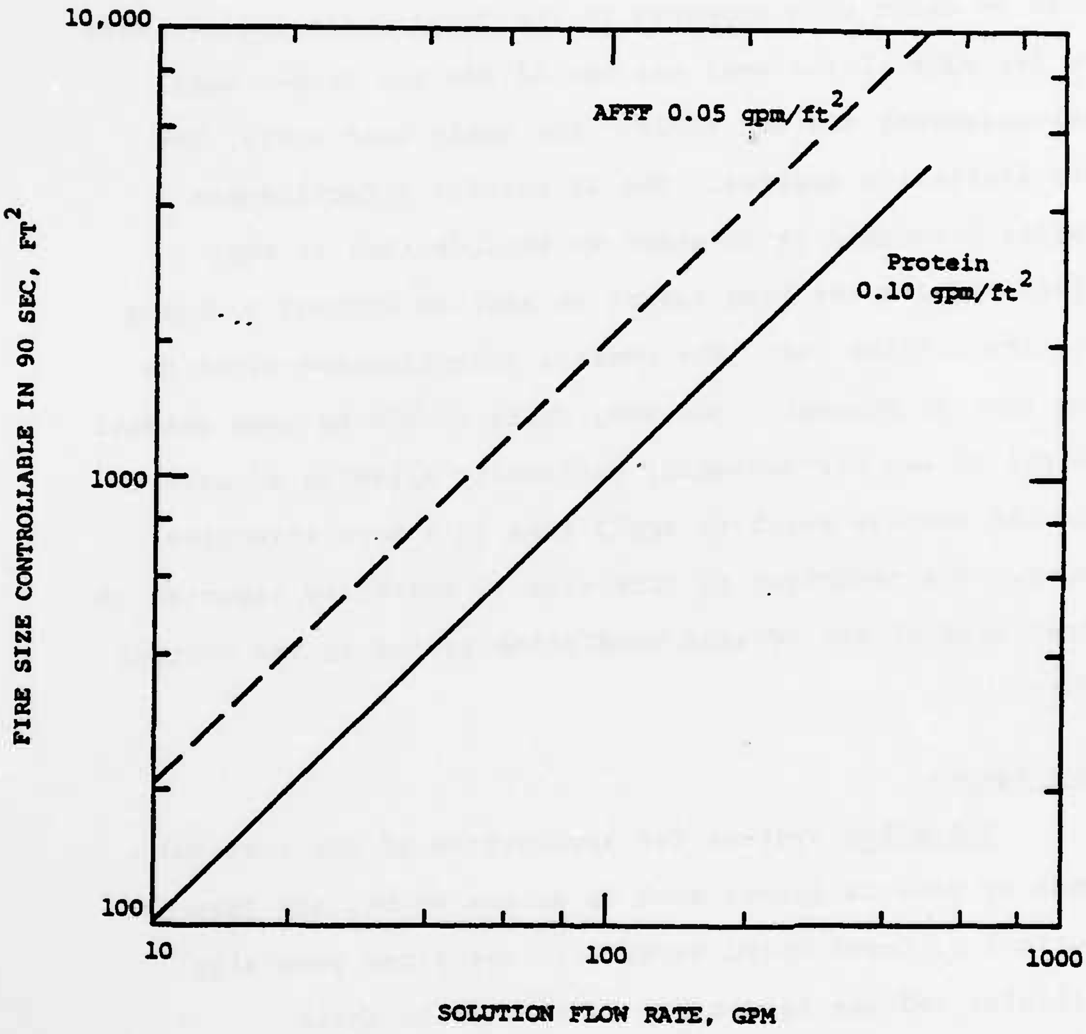

FIGURE 2. APPROXIMATE FIRE AREA CONTROLLED IN 90 SEC BY GIVEN FOAM FLOW RATES.

fire tests on the M/V Rhode Island at Mobile, AL, each using more conventional equipment, the estimates should be reasonable. One limiting factor on total pool size that could be dealt with appeared in the Coast Guard tests: when the far edge of the pool was out of monitor range, total extinguishment did not occur. For small boat crews, the same limitation applies. The 25 percent effectiveness example discussed is intended to include some of that effect. Where the foam cannot be applied without plunging into the burning fuel, the overall effectiveness might be less than 25 percent. However, there should be some gradual control in any circumstance, eventually allowing advance to a better vantage point to apply foam in a more effective manner. The reduction in fire size is therefore expected to offset some of any adverse conditions acting on the control effort.

Other Agents

Installed systems for application of dry chemical agents or gaseous agents such as Halons or CO_2 are just not practical on Coast Guard vessels of the sizes generally available, and the agents are so limited in their applicability, that they are not useful as a first response system. They suffer particularly from the heat-up and reignition problem inherent in slow-response attack. This comment is not addressing installed systems for damage control, but systems used for attacking fires external to

the vessel. Because of limited range and limited general effectiveness for their weight and space requirements, only portable systems should be carried. For these agents, 30-pound extinguishers are about the largest useful capacity. At least one CO_2 or Halon and two dry chemical portables should be carried in addition to those located for self protection.

Estimated Firefighting Capability: Example by Scenario

The amount of Class B, flammable liquid fire that can be controlled is variable, as indicated in Figure 2, although there are the practical limits for a single small boat which were mentioned.

Class A fires, fires in ordinary combustible solid materials, are less straightforward in their response to the application of water. Structural fires, cargo hold fires, and ship structural fires share common unpredictability, principally related to amounts of material or structure burning, accessibility of the fire base (embers), and progress of the fire. The problem inside enclosures is further complicated by sometimes intense heat into which firefighters cannot advance and the possibility of the phenomenon of flashover.

For purposes of visualizing the amount of structural fire that a single small boat and its crew might control and perhaps subsequently extinguish, some general estimates were

made. These estimates assume a fire fairly well advanced in area (walls, ceilings, etc.) but not to the point of having weakened basic structure or of having consumed the structural veneer. The estimates are based upon discussion with company officers from a few departments, emphasizing limited crew for handling hose, the possible variations in access and in other conditions (wind, direction of approach, essentially no other equipment, etc.), as well as the limited training and experience of the crew. The firefighters naturally tended to estimate in terms of their own type of operation and experience, and generally started with a fairly high estimate of capability. As their understanding of the scenario increased, the estimates lowered until each was fairly firm on the estimates. The results were couched in terms of an ordinary detached automobile garage of frame and wood-shingle roof construction, perhaps with some Class A contents but no car. The firefighters were agreed that a crew of four could probably advance only a single 1 1/2-inch hose for 100-gpm capacity. The general consensus of the size structure that could be saved if roughly half the structural envelope was involved in fire at arrival was as follows:

100-gpm capability--one 12 ft x 22 ft garage

300-gpm capability--a double-car garage

500-gpm capability--4 single-car garages equivalent

These estimates were essentially in agreement with our own estimates, based upon observation and the knowledge that for controlling fires in similar residential structures, water use varies from fire to fire from some maximum gallonage to as little as ten percent of that maximum gallonage. Those results were observed in performance of firefighters in a large fire department. The fires were not unlike those in our scenario, except some were smaller and all were indoor fires.

Our analysis of the scenario assumes only ten to fifteen percent of water flow to be available in useful form. Not all of that will be applied with effect. On a precisely comparable basis, we expect that the Coast Guard crew's performance would not be demonstrably different from that of municipal firefighters, that is, with conditions the same for both.

As a practical example of what these estimates represent, we do not believe the crew of a Coast Guard vessel under 65 foot could alone control a small cargo hold or engine room fire, using only its own resources. Given assistance by the ship's crew, however, control of such fires (defined elsewhere in this report) should be well within their capability.

Thermal Limitations on Firefighting

Whether fire is being fought from the boat or from lines ashore, the limited "throw" available restricts success as fire size increases, because heat from the fire begins to exceed tolerance. Figure 3 illustrates distances at which radiant heat fluxes of 1600-Btu/hr-ft^2 are produced from fires from pools of a hydrocarbon. The 1600-Btu/hr-ft^2 heat flux curve represents a thermal radiation level at which unprotected skin burns in 30 seconds. Table 2 presents other effects of selected thermal radiation levels.

Figure 3 indicates that if all conditions are adverse, a 20-foot pool fire produces pain flux levels at 100 ft, which is near the maximum range of Coast Guard pump/nozzle combinations. While it is clear that conditions are rarely such that a 20-foot diameter fire cannot be closely approached, it is obvious that fire sizes can occur which will be difficult to approach for fighting. For the smaller boats with crews of three or four, the risk seems greater because of lack of backup manpower if needed, particularly, for example, where part of the crew has laid hose from the boat to get to the fire. In this case, manpower is necessarily divided between boat and shore.

Table 3 provides some estimates of the length of time crewmen might voluntarily remain within 100 feet of hydrocarbon pool fires of various sizes, if they have various levels of protection. Again, these estimates assume

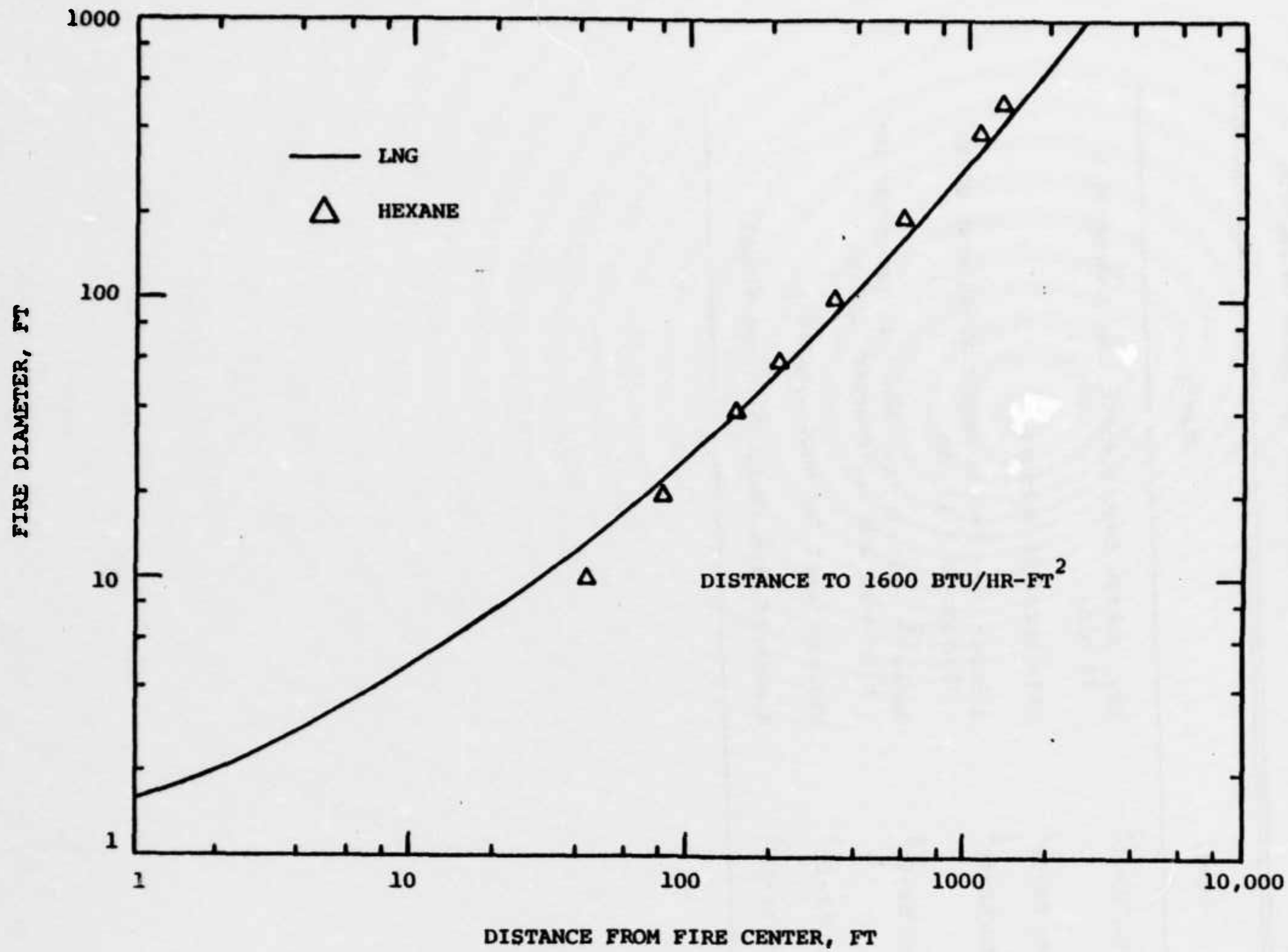

FIGURE 3. RADII OF INTOLERABLE ENVIRONMENT ZONES AS A FUNCTION OF POOL FIRE SIZE.

TABLE 2. EFFECT OF THERMAL RADIATION EXPOSURES ON OBJECTS

Radiation Level	Effect
1,363 Btu/hr-ft^2	Dry, cotton duck turnout coat undamaged > 15 min.
1,600 Btu/hr-ft^2	Skin burns 30 seconds.
2,916 Btu/hr-ft^2	3-layer, dry cotton duck turnout coat burns through in < 15 min.
3,677 Btu/hr-ft^2	Nomex® turnout coat smoking, vapor barrier blackened and stiff after 15 min.
4,000 Btu/hr-ft^2	Minimum level for wood ignition.
12,000 Btu/hr-ft^2	Blackened pine ignition in one minute.

TABLE 3. ESTIMATED FIRE FIGHTER TOLERANCES

I.	ORDINARY CLOTHING	FLUX/TIME		FIRE SIZE FOR 100 FT RANGE
	Long Sleeves	1,600	2 min	1,500 ft^2
	Fog in Front	1,600	10 min	1,500 ft^2
		5,000	2-5 min	4,500 ft^2
	Wetted	5,000	10-15 min	4,500 ft^2
II.	TURN-OUT GEAR			
	Dry	1,600	Indefinitely	1,500 ft^2
		5,000	2 min	4,500 ft^2
	Fog in Front	5,000	10 min	4,500 ft^2
		10,000	1-2 min	12,000 ft^2
	Wetted	5,000	Indefinitely	4,500 ft^2
		10,000	2-5 min	12,000 ft^2
III.	PROXIMITY SUITS			
	Dry	10,000	Indefinitely	12,000 ft^2
	Wetted	Failure Dependent		Any Size

worst conditions. Ordinary clothing does not include coats or heavy winter wear; turn-out gear is normal firefighter turnout coat, helmet, boots, etc.; proximity suits are the highly fire-resistant, aluminized full-protection suits sometimes called an "entry suit." Table 4 presents some estimates of tolerance times in enclosures.

Many factors are usually active to make conditions tolerable for closer approach to a fire. The flux data used here is for pure, clean-burning hydrocarbon and therefore higher than for many other fuels. Wind can be helpful in tilting the flames and otherwise reducing the effective flux. Fog shields and wetted clothing are quite helpful, as long as cooling is constantly maintained to prevent scalding. Clothing woven of man-made fibers particularly needs to be kept wetted. Plastic helmets or hard hats have softened due to heat and are alleged to have draped about the head, cooled, and had to be cut away.

Clothing similar to firefighter turnout gear has been suggested as an improved protection for boat crews. Such gear, like Nomex® suits has a disadvantage for relatively inexperienced people by allowing them to proceed to a position of excessive risk. In addition, firefighter gear would probably be more dangerous if the wearer went overboard. Some boat crewmen felt that current winter clothing issued could be improved. The comment related only to firefighting conditions at a few fires, perhaps where the crew were constantly in freezing spray for hours.

TABLE 4. FIRE FIGHTER TOLERANCE IN HEATED ENCLOSURES*

"Normally Expected Fire Fighter Exposure Time"	Air Temperature °F (°C)	Radiant Flux Btu/hr-ft^2
30 min	104 (40)	159
15 min	203 (95)	317
3 min	482 (250)	555
10 sec	1500 (815)	13,316

*Units modified. Data from F. J. Abeles and V. Himel, "Project FIRES." Phase 1B Final Report, NASA Contract NAS 8-32329, May 1980.

The fire resistance of the available vessels is not a practical limiting factor with respect to firefighting, since virtually all of the vessels require exposed manning of hoses and monitors. The vessel that seems more likely to be at risk from thermal effects is the 32-foot ports and waterways boat. Despite its fire-resistant materials of construction, it is not fireproof. Since the crew can remain shielded somewhat from the thermal radiation, the boat can proceed too close or remain too long. Also, if a sudden eruption of burning fuel splashed over the boat and pilot house, fire resistance will be less than that of metal boats. These are remote but possible problems the 32-foot boat might encounter.

The question of capability has thus far been addressed towards the problem of the smaller boats. The discussion has essentially centered on the single small boat and its crew. This has appeared to be the most manageable method, since to discuss the subject in terms of multiples of boats and the various possible mixes of boats would not only be complicated but entirely hypothetical. While it is true that the case of the single small boat is not as serious as the argument has implied, and that additional boats reduce the danger, it is also true that the additional boats do not reduce the individual risk of getting into difficulty.

One of the reasons that Coast Guard boats can be expected to advance beyond a point which a judicious and experienced firefighter would not go is the general lack of experience of the crew. Even very small fires are rare, so opportunities for experience are few. In addition, many of the boat crewmen may accept excessive risk because of a greater commitment to a perceived duty than is actually expected.

An alternative classification of firefighting capability that was first considered was based essentially on pumping capacity, on the principle that the capability evaluation should relate to a single, largest fire that might be attacked. In this classification scheme, the classes of firefighting capability was represented by these vessel groups:

100 gpm - boats from 30 foot (excluding the 32-foot port safety boat) through the 65-foot WYTL

300 gpm - boats from the 75-foot WLIC through the 210-foot medium- endurance cutter

500 gpm - largest vessels

Upon further consideration, in terms of overall general purposes, and in particular considering the few larger fires available for encounter, classification into more than two groups on the basis previously discussed appeared more pertinent to the problem. For example, the 100-ft WYTM "A" has two 1200-gpm pumps powered by diesel pump engines. For some fires along the waterfront and for

fires aboard boats up to about 60 feet, maneuverability and possibly draft will limit use of the available flow, partly because of the relatively low 75-psi pressure rating. For the purpose of supplying pumper engines ashore, or in ship fires where boarding is possible and the boat can be lashed alongside, the full capacity can be used. Those types of occasions appear to be too infrequent to use as a criterion to apply. The events at which that capacity cannot be used will be much more frequent. In other words, the question we are attempting to answer is "what is the capability of the boats against the broad spectrum of fires, particularly those of higher frequency of occurrence?"

The 32-ft port safety boat is in some respects in a class by itself, because its design incorporated some features useful for firefighting. These special features include the significantly higher speed; good pumping capacity for the vessel size, with pressure capability to make that capacity useful; installed foam system, which allows more effective use of the crew; the installed monitor operated from the pilot house; and the deck space available for a special pump package. Less desirable features are the possibility that the boat may at times have problems in station keeping, particularly if the special pump package is used; the hull design would appear to limit use of the boat in even moderate seas; and the design of the sea chest for fire main and engine cooling was reported in one case to

have allowed oil spilled from a ship to be ingested in the fire pump and engine coolant systems. The fire-resistant fiber glass pilot house could be damaged under some fire conditions, particularly since a closer approach to a large fire is possible because the crew has the protection of the pilot house.

PHASE II RESULTS

Phase II as finally revised called for concentration of effort on the single Port of Philadelphia. Under the revised version, additional interviews and any other information obtainable were to be reviewed. The principal effort was to be directed towards identifying problem areas, potential weaknesses, and resources. Particular effort also was applied to trying to determine whether more reliable, planned response systems for large and catastrophic fires were in place.

General Port Characteristics

The area of responsibility of the Captain of the Port, based at Gloucester City, NJ, extends essentially along the Delaware River from Trenton on the north, down the Delaware River to the Bay, then north along the New Jersey shore past Cape May and south along the Delaware shore. The major concentration of port activity occurs on both sides of the river in the Philadelphia area, starting below Paulsboro, NJ, on the east bank and extending north of Camden, NJ. On the west bank, the highest concentration extends from the Bucks County Line north of Philadelphia southerly to the Delaware state line south of Marcus Hook, PA. The New Jersey side from below Paulsboro to Gloucester City is occupied mostly with scattered petroleum and

chemical tank farms and loading facilities. From Gloucester City, facilities are for general cargo, break bulk, refrigerated storage, shipbreaking, ro-ro (roll-on/roll-off) and container facilities. Much of the cargo is held in open storage. On the Philadelphia side, marine operations are sparse from the county line to Frankford Creek, although there are many large waterside buildings. Immediately south of Frankford Creek are the Philadelphia electric and gas company facilities. The gas company's liquefied natural gas storage tanks are set back about 1500 ft from the river's edge. Between the gas and other storage tanks and the river is a very large marine terminal for general cargo, containers, and bulk liquids. The adjacent Port Richmond facilities provide piers with bulk ore handling equipment and ro-ro, general cargo, bulk chemicals, and bulk grain shipping and receiving equipment. South from Port Richmond to Penn's Landing the waterfront is almost solidly lined with piers handling materials from bulk construction material and sugar to general cargo. From Penn's Landing to the Philadelphia Naval Base, piers again line the river, including facilities for general cargo, vehicles, containers, bulk ore and other materials, and bulk petroleum and chemical products. Nearest the Naval Base is another large marine terminal complex for break-bulk, containers, and roll-on/roll-off berths.

The Naval Base has been considered by some Philadelphia authorities as the facility which separates the high and lower fire risk areas of the port. In a 1976 letter to MARAD, the Director of Operations for Philadelphia Port Corporation described the area:

> "The critical fire risk areas are along the Schuylkill River below Passyunk Avenue and both sides of the Delaware River exending from Marcus Hook to the Betsy Ross Bridge, a distance of about 25 miles. Within this area, there are 6 oil refineries, 6 tank farms, 2 grain elevators, the U. S. Naval Base, 93 ship berths and hundreds of diversified industrial sites. The lower risk area extends 28 miles north from the Betsy Ross Bridge to Trenton and south 20 miles from Marcus Hook to Delaware City where a seventh refinery is located, so that the fireboats cover a total distance of about 75 miles on the Delaware and Schuylkill Rivers."
>
> "Since 1969, the Philadelphia fireboats have extinguished 117 major fires in the critical risk areas and 30 fires in the lower risk areas. Over 50 lives have been lost and the economic loss has been well in excess of 50 million dollars including the tankers "Elias" and "Corinthos" which were destroyed at their berths."

The Naval Base lies east of the Schuylkill River where that river enters the west bank of the Delaware River. Upstream along the Schuylkill are two cargo piers and a grain loading facility. The next facility is a very large refinery and tank farm. Other smaller tank farms are located further up the river.

Southwest along the Delaware (Pennsylvania shore) from the mouth of the Schuylkill is a military reservation, abutted at the southwest by runways of the Philadelphia International Airport. At the river edge is a tanker

terminal (scene of the Elias explosion) and a second tanker terminal a half-mile beyond. From south of Essington, PA, the Pennsylvania shore is heavily populated with tanker terminals, refineries and petrochemical plants, and tank farms. This developed area extends from north of Chester, PA, southerly along the river almost to Wilmington, DE.

The Port of Wilmington, DE, lies along the Christina River from its junction with the Delaware. The major products handled at Wilmington are ores, lumber and wood products, frozen foods, and, according to port authorities, a relatively low traffic in oil and chemicals. Downstream of Wilmington, the shores of the Delaware are considerably less developed, with the few facilities constructed serving only local industry.

Outside the port areas discussed, fire potential which might require Coast Guard assistance appears highest at the mouth of Delaware Bay. The potential appears greater at this point because of convergence of sea channels, pilotage area, and anchorage within relatively limited space. Although the occurrence of fires and collisions in the area between Wilmington and the mouth of Delaware Bay is historically extremely low, because of this congested zone, the potential appears higher at the mouth of the Bay than in the remainder of the lower river. Although some vessels with fire aboard might be able to proceed up river to assistance near Philadelphia, a tanker suffering

collision-fire may be unable to travel close enough to Philadelphia to be assisted by fireboats or even large tugs. Consequently, a fire casualty in the Bay might be a drifting fire for several hours, posing some threat to other vessels. Shallow water should prevent threat to developments along the shore. Fortunately, resources available at Cape May should be able to avert large-scale fire spread to other vessels, unless many of Cape May's resources are committed to other search and rescue efforts. In that case, response capability is going to be several hours away.

Changes in the Delaware River Ports in the next few years are not expected to cause significant changes in general hazard levels, although increases in traffic and some changes in commodities are expected. As a result of increasing interest in the use of coal as fuel, facilities on the Delaware are expanding capacity and new facilities are under construction: Pier 124 is being refurbished to double its capacity to 3,000 tons/hr; Beckett Street terminal in Philadelphia and the Wilmington, DE, Terminal have begun handling coal. Coal handling facilities in Camden, NJ, are being constructed, and negotiations are underway to develop a major coal facility at Port Richmond.

The potential for a work-port for offshore drilling operations has diminished because of lack of major discoveries. Similarly, discussion of a deepwater facility for deep-draft vessels in Delaware Bay has diminished,

although increasing shipments of coal added to its potential uses for oil, chemicals, grain, and metals might revive interest.

Oil refineries, chemical plants, and chemical tank farms are all expanding capacity. Additional expansion of all types of facilities might occur as a result of a new study of rail and port facilities being funded by MARAD and performed by Booz-Allen and its subcontractors. A regional group presently studying the feasibility of a tri-state port authority may provide additional impetus, if such an authority is formed.

Increased shipbuilding or ship renovation is expected in the Philadelphia Naval Yards and Sun Shipyard to accommodate the U. S. Navy's SLIP program and the anticipated increase in defense forces.

Port Authorities and Disaster Response Organization

The Delaware River Ports are operated under several authorities, the major ones being the Philadelphia Port Corporation, the South Jersey Port Corporation, and the Port of Wilmington under the Board of Harbor Commissioners, Wilmington, DE. Liaison and some joint operations of the States of Pennsylvania and New Jersey are provided by the Delaware River Port Authority of Pennsylvania and New Jersey. Some liaison between the Delaware River Port Authority and the State of Delaware occurs through the

Delaware River and Bay Authority which operates a bridge near Wilmington connecting Delaware and New Jersey. For purposes of promotion of maritime commerce, all three states participate in a loose organization called Ameriport, which operates mostly through the Delaware River Port Authority, World Trade Division.

In accordance with civil defense planning requirements, and with guidance and assistance from the U. S. Maritime Administration, an organization called the Delaware River Port's Council for Emergency Operations has been developed. Pennsylvania and New Jersey have officially designated both the Council and the Delaware River Port Authority as Civil Defense Agencies. Three Delaware county civil defense offices and the Wilmington Marine Terminals also participate. The Council therefore lists as members the civil defense offices of all counties along both sides of the Delaware River from Trenton, NJ, to Cape May, NJ, and Lewes, DE, at the mouth of Delaware Bay. Most port cities, major facility operators, and a number of federal agencies are members or have designated coordinators enrolled. The area of responsibility of the Council for Emergency Operations is roughly the same as that of the Captain of the Port of Philadelphia. Under contingency conditions, the port area is not limited by statute but is that area which is required to operate the ports.

The Council for Emergency Operations was established in the early 1970's, and issued the first revised emergency operating plan in 1973. The plans provide charts of organization, missions, a very general operational guideline, and a list of emergency coordinators, emergency agencies, and service organizations. The Council meets monthly and usually has a guest speaker presenting topics such as the relationship of the COTP with the Ports of Philadelphia, emergency planning activities of MARAD, or an update on off-shore drilling activities. The Council has participated in planning for pollution control, weather forecasting and alerting, river traffic management technique, and emergency medical services coordination.

The Council has established and equipped emergency operating centers and a communication center located in Camden, NJ, with five widely scattered alternate locations.

Although it is difficult for an outsider to fairly evaluate an organization such as the Emergency Council, our opinion is that the actual capabilities of the Emergency Council are very limited, particularly in terms of directing a rapid, effective response. The Council is organized to respond to widespread disaster from nuclear attack, and secondarily to other widespread disasters. Consequently, for smaller emergencies such as a ship or facility fire, even though it is at the level we have called catastrophic, the Council does not intiate action. Typical low-level

activity occurred in response to hurricane potential in August, 1976, when the Council activated its Control Center to monitor the storm's characteristics and relay that information to marine facilities.

Although the Council has minor detail in its emergency operating plans for planning and coordinating firefighting activities after an attack, as well as could be determined, a practical organization and plans are not in place. In fact, it appears likely that a required response would be organized after attack, and generally on the same basis as presently occurs, a more or less informal mutual aid basis. The Council has had a considerable interest in improving marine firefighting capability for the Port, an interest that was initiated by the Elias fire and intensified by activities of Congressmen from New York and Pennsylvania who introduced a bill (H. R. 362) to strengthen and fund MARAD activities promoting improved marine firefighting. The Council sponsored a Fire Boat Task Force which examined possible designs and prepared specifications which it recommended to Philadelphia as replacement for the city's present fireboats. The fireboat project depended upon federal funding which was never made available, so no new fireboats were procured.

In summary, although the Council for Emergency Operations is a continuing organization which could probably be successful under attack and post-attack conditions, it is

not set up to respond to short-term emergencies. Although it might provide a useful forum for creating interest in improved firefighting capability, that interest would be centered around Philadelphia and Camden, rather than for the entire Delaware River and Bay.

<u>Firefighting Response Resources</u>

The U. S. Army Corps of Engineers has an emergency or disaster assistance organization which has an office in Philadelphia. Discussions with this office indicated that this organization operates at regional-scale disasters such as floods or hurricanes. The logistics of moving large quantities of equipment, men, and materials over large distances are structured in such fashion that response to short-term emergencies is not possible. Even though a certain amount of possibly useful equipment and materials may be in the general Delaware River area, it appeared that acquiring use of these resources through this office would be too time-consuming to be practical. Generally, the advice was that for short-term response from the Corps of Engineers, better results would be achieved by request through the local commander's office.

With the exception of Philadelphia, fire emergencies are handled through county civil defense or emergency communications centers. Although these centers may also be designated emergency operating centers, they do not in practice manage fire-related emergencies and are not set up

for coordination tasks. Their major function is to provide communications and notification. In practice, when outside assistance is needed, direction comes from the volunteer or municipal fire department in whose jurisdiction the fire occurs. Dispatch of ambulances is generally also at the request of the fire company in charge. No other coordination activities originate at the control centers.

The Philadelphia Fire Dept. operates essentially independently of all the surrounding towns, boroughs, and counties. In addition to its very large land-based firefighting organization, the City operates three fireboats which are stationed at locations strategic to the city. Because of their combined missions of firefighting, rescue, salvage, and recovery of bodies, the boats are not necessarily located for optimum response for controlling fires. In addition, they are not located with particular reference to any other jurisdiction. One boat is located fairly far downriver, but its location is for accomodation to Philadelphia International Airport, rather than because the location is close to dense industrial development. The fireboats are all over 30 years old. They are eighty-foot, 600-horsepower, tugboat-style fireboats with 30-foot water towers, fire pump capacity of 6,000 gpm at 150 psi, and a maximum speed of 13 knots (when new). High wake (as well as age) limits their speed considerably below the maximum on most runs.

The Philadelphia Fire Department is reported to have scheduled in its 1986 budget a one-million dollar item to provide one new fireboat. Tentative plans for the proposed fireboat are for a size and general design similar to that of the present fireboats, but with a higher speed capability and with considerable automation to reduce crew requirements.

There are also plans for the construction of a new emergency response facility which will provide accommodations for several different agencies. The new facility will be built on the Delaware River at Washington Avenue, roughly at the present location of Piers 46 and 48, downriver one and one-half miles from the Ben Franklin Bridge and one mile from Penn's Landing. The location is almost directly across the river from the Camden, NJ, terminal. Present plans are for this facility to house the Captain of the Port; the Marine Inspection Office of Philadelphia; a Philadelphia emergency response communications center; a Philadelphia fireboat; a Philadelphia Police launch; a small rescue boat; and possibly facilities for an area disaster-response control center. Recent information from local sources indicated that the USCG boats and personnel will operate from this new location, and that the Gloucester City Base will be disposed of by sale.

Philadelphia has by far the largest paid firefighting contingent along the Delaware. The only other moderate-sized paid departments are at Trenton and Camden, New Jersey, and at Wilmington, Delaware. Other departments of boroughs and townships are mostly volunteer although a few have paid drivers which sometimes improves response time. In Pennsylvania, for example, 2,980 or 99.7% of all departments are volunteer or only part-paid. The departments or companies may be private, non-profit corporations or have a more direct relationship with the political entity they serve. The unit may own some or all of its large equipment or the equipment may be owned by the city. Generally, the volunteer companies in the Delaware River area have a reputation for being well-trained and competent.

Contrary to what might be expected, volunteer departments may have newer or more advanced equipment than that of large municipal departments. Ladder pipe trucks and snorkel or articulated boom trucks are relatively common. Obviously, however, some types of equipment such as large airport crash trucks are not in volunteer company equipment. The only volunteer company along the Delaware reported to have a boat with firepump capacity is at Bristol, Pennsylvania. That boat is reported to be 16 ft long with pumping capacity of 3,125 gpm.

A well-trained and well-equipped firefighting contingent is stationed at the U. S. Naval Base at Philadelphia. This contingent uses three YTM's or YTL's. Because the vessels are not limited to firefighting activities, they are not always available and may not even be in the Delaware River and Bay. Additionally, they may not be available if they are engaged in operations at the Base and, even if engaged in firefighting outside the Base, they may be recalled to the Base on short notice. When these vessels are dispatched for firefighting service outside the Base, the regular crew is usually augmented by two or more firefighters from the Base Fire Department. This probably improves the potential overall firefighting capability of the boats, particularly in a boarding situation. Very recent information indicates that all Navy tugs have been transferred from Philadelphia to other stations, and there are no immediate plans for their return or replacement.

One other source of waterborne firefighting capability is available in the Philadelphia area. This source is the tugboats operated in the area by Mobil Oil Corp. and Texaco. The availability of these vessels (three tugs), like the Navy tugs, depends upon their presence in the area and their not being in use or scheduled for operation at another port. At times, none of the three is in port.

Other commercial tugs have assisted at fires in the Delaware and Schuylkill rivers. Generally, the commercial tugs are small with limited pumping capacity and limited, if any, foam agent concentrate. These tugs are rarely available for long sieges of firefighting activity, because they are required for continued maritime activity in the port, and because additional crews are not maintained to relieve the crews on duty.

Coast Guard Resources for the Delaware River Ports

The Captain of the Port of Philadelphia is located at the U. S. Coast Guard Base, Gloucester City, New Jersey. The Base is located about sixteen miles downriver from the northern end of Philadelphia port development and about four miles upriver from the mouth of the Schuylkill River. Running time from the Base to potential fire locations in the immediate Philadelphia Ports area may be two hours or more, that is, to the Mud Island area upriver or to Marcus Hook downriver. Running time is also affected by currents, tides, and weather.

The patrol and other vessels available at Gloucester City Base in June, 1981, were two 32-foot port security boats, one 41-foot UTB, two 65-foot WYTM (Cleat and Catenary) and one 157-foot buoy tender (the Red Oak). Three P-250 pumps were available on line.

Of the boats available at Gloucester City Base, only the two 32-foot port security boats are fitted with direct fixed piping to a firefighting monitor. With their 500-gpm separately driven fire pumps and installed foam proportioning system, these vessels have significantly greater firefighting capability than the other boats. The large buoy tender, which could easily accomodate additional portable pumps on the buoy deck or on a higher level platform near the stern, apparently is somewhat limited as a firefighting vessel because of limited maneuverability and

deeper draft than the smaller boats. In some boarding firefighting situations, however, the buoy tender could be more effective because of its larger crew, particularly if it had additional portable pumps aboard. The buoy tender has an advantage in foam concentrate carried, 100 gallons compared to 40 or fewer gallons on the 41-foot and the 65-foot tugs. It might be possible at times to use the bridge wings as a firefighting platform, which would provide a much better vantage point than is available on all the other boats. The 65-foot tugs have more load-carrying capacity on a temporary basis than the smaller boats. Because one of the tugs (the Cleat) is essentially a front-loading buoy boat, the space forward of the wheelhouse is unhandy for firefighting. The Catenary has a deck area rather than a well forward of the wheelhouse. Consequently, the Catenary, particularly with a P-250 pump supplementing the installed pumps, could be the best of the boats at Philadelphia for firefighting. It normally operates with a crew of four, which imposes a serious limitation. Because the installed pump takes power from the main engine, a reasonable balance of maneuverability, stationkeeping, and waterflow to fire lines or monitors is not easily achieved. The task is complicated further because power is transferred only in the engine room, which diverts one of the already limited crew from full-time participation in handling monitors, hoses, or foam concentrate.

The number of boats available for dispatch at any one time is variable, depending upon maintenance schedules, crew availability, and prior assignment. The priority assignment is always search and rescue, and a boat engaged in search and rescue would not be recalled for fire, unless the new mission had higher probability of successful rescue. Boats on routine patrol are available if crew change is not imminent. Most other assignments except SAR and perhaps pollution control would be aborted for a response to fire because of the probable need for search and rescue activities at the fire scene. With the present complement of boats, probably two would be available for immediate response with a maximum of three more for later response.

There is at times a fairly significant Coast Guard response capability at Cape May, New Jersey, as compared to Gloucester Base, although distances are such that vessels rarely or never respond to assist beyond the normal operational areas. The Cape May operational area meets the downriver operational area perimeter of Gloucester Base at Ship John Shoal Light near Bombay Hook where the River enters the Bay proper.

Cape May operates three HH-52 helicopters. Boats based at Cape May vary with season. In summer, Cape May has two 41-foot patrol boats, one 44-foot patrol boat, and two or three 19- to 21-foot Boston Whalers which can carry a P-60 pump. In winter, a 41-foot patrol boat at the summer SAR station at Fortescue, NJ, returns to Cape May.

Three cutters are stationed at Cape May, although they are not part of the complement of Cape May Station and are dispatched by New York. These vessels are an 82-foot WPB, a 180-foot buoy tender, and a 210-foot medium-endurance cutter.

Additional SAR stations along the Atlantic are at Indian River Inlet, which has one 41-foot and one 44-foot patrol boat year round, with an additional 41-foot in winter. That additional 41-foot boat remains at a summer SAR station at Roosevelt Inlet in season. Great Egg Harbor Inlet Station at Ocean City, NJ, has one 44-foot, one 41-foot, and one 21-foot boat. The summer SAR station at Townsend Inlet has a 30-foot patrol boat which returns to Great Egg Station in winter.

Several portable P-250 and P-60 pumps are available at Cape May and Great Egg Inlet. Only P-60 portable pumps are provided at the summer SAR stations.

At past large fires in the Philadelphia area, all of which have been no further downriver than the Marcus Hook area, circumstances have been fortunate in that Philadelphia fireboats were available and able to respond, two or more Navy tugs were available and also able to respond, and at least one large oil company tug was in port and able to respond. Circumstances are conceivable in which only one or two fireboats might be available, and any other assistance would have to be obtained from smaller commercial tugs.

With adverse winds and tides or currents, and particularly with a large spill of burning light crude moving in patches on the water, the system available might be unable to contain the fire to the general area of the ship. That fairly large fires can be ignited at a distance was demonstrated at the Corinthos fire. While some terminals and facilities might beat the fire back from piers and fixtures using installed monitors and available handlines, their ability to react will depend upon time of day or time available to assemble crews. Some aid usually should be available if they are called and allowed to enter the facility.

COMMENTS AND SUGGESTIONS

This section summarizes only what are considered to be more relevant or substantive results of this study. Considering the limited success of the overall project, the information provided here is not considered to have the technical validity normally expected of conclusions and recommendations, and so are offered only as comment and suggestion.

Comments related to the Delaware river ports are essentially those we believe are practical. Relevance of the General Comments is probably on a port by port or region by region basis. Many ports probably have absolutely none of the potential deficiencies discussed, or even a different set of problems not represented by the ports examined or by the literature, accident reports, and statistics. Some may recognize a problem and perhaps even a usable solution.

Comments on Delaware River and Ports

1. Resources under command of the Captain of the Port of Philadelphia appear to have decreased in the period 1979-1981.

2. Major waterborne resources previously available from the U. S. Navy and industry are reported to be either substantially reduced or no longer available.

3. A significant change in operating policy for dispatch of fireboats by the Philadelphia Fire Department is considered to reflect an increasing burden of cost and an increasing concern over equipment (fireboats) because of their age.

4. It is possible if not probable that the currently inequitable practice of the City of Philadelphia providing the only organized high-capacity waterborne firefighting capability for the ports on the Delaware River is rapidly becoming both intolerable and impractical.

5. With the possible exception of high-capacity waterborne fire pump capability and a capability of rapid response, adequate resources can be assembled for protection of the ports.

6. Increasing waterfront trade and industrial activity may increase the potential for the occurrence of fires, although the hazards from fire are not expected to increase as much as might have been expected had earlier plans for increased petrochemical activity from offshore drilling materialized.

7. With the exception of facilities along the Schuylkill and possibly at Port Richmond, greater public hazard appears to be concentrated at excessive distances from major waterborne firefighting capability. That type of capability is required because of the type and size fires constituting the threat. However, the term "excessive

distance" and the level of the "requirement" for "adequate" firefighting response are moderated by the locally perceived level of public hazard.

8. It appears doubtful that a practical, dependable, organized massive response mechanism is in place, particularly for response to the vicinity of Paulsboro, NJ, Marcus Hook, PA, Wilmington, DE, Pea Patch Island, or the mouth of Delaware Bay. Public hazard at Pea Patch Island and Delaware Bay is considered low, and only moderate at Wilmington, DE.

9. The support for port safety expressed by various organizations in the area on both sides of the river from North Philadelphia to Marcus Hook is probably the most effective potential asset available to the Captain of the Port, if it is desirable to strengthen, formalize, and improve the dependability of a mutual aid response capability.

10. Our perception of the general attitude of industry is that it reflects alignment of industry versus political elements more than mutual concern for resolution of a potential problem. This comment is based on impressions of the Channel Industries Mutual Aid Association at Houston compared with industry on the Delaware.

11. We believe that if the attitude of industry along the Delaware is as we perceived it, the Captain of the Port could induce changes in that attitude which would

develop an environment conducive to support for improved response capabilities.

12. The Coast Guard Reserve might be a major resource to provide programs through which the Captain of the Port could improve relationships of industry, local agencies, and the Coast Guard.

13. Establishment of a strong and active Coast Guard Reserve Firefighting Coordinator Program, preferably with some direct participation by FIC L. J. McPolin of CGRU Long Beach #1, is highly recommended. Chief McPolin's assistance is recommended particularly to aid in design of programs mentioned in Item 12.

14. Centralizing the major response agencies at the new Emergency Response Center being developed at Philadelphia should vastly improve coordination capabilities within the port of Philadelphia. If the recommended Coast Guard Reserve activities are instituted, their activities should be integrated with others at the Emergency Response Center.

15. A significant improvement in response capability could be provided by two fireboats with 20- to 25-knot speed, 2,500- to 3,000-gpm firepump capacity, and 300- to 500-gallon AFFF foam concentrate tank. These boats should be located in the vicinity of Paulsboro, NJ, and Marcus Hook, PA.

16. A strong Tri-State Port Organization chartered to contribute to all aspects of port development should be a vehicle through which resources for Delaware River port safety could be developed. Recent expressions of interest in tri-state cooperation appear to be geared mostly to development of port facilities and expansion of trade. A compact which could provide specialized facilities, equipment, and personnel for mutual needs such as firefighting or pollution control response would be the most practical means by which improved marine firefighting capability could be provided for the Delaware River complex.

17. Developing a firefighting contingency plan for the Delaware River Ports is a laudable activity. However, we believe a strong organization is needed as an organizational vehicle; dependable commitments from participants are necessary; willing industry participation and support are absolutely required; unmistakable, unanimous policy regarding who will be the "focal person in charge" at any incident must be achieved; and many elements of the plan must be activated at least twice a year to ensure dependability and commitment, to improve coordination, and to establish familiarity and mutual trust among participants.

18. Although some plans and some loose relationships now exist, an actual system to institute those plans is not in place. Consequently, if a large area response is

required, it almost has to be developed on the basis of serendipity rather than organization. This method results in limited coordination, unbalanced forces, and a potential for lasting ill-will in the future.

General Comments and Suggestions

1. In many areas, current Coast Guard firefighting policy would be absolutely practical only if alternative federal, state, or joint-state firefighting resources were available. The policy is presently practical in terms of Coast Guard equipment, manpower, and presence (availability in any given location), but not in terms of what must necessarily be attempted by Coast Guard men and boats.

2. Early improvement of the firefighting capability of all boats or of all of the COTP installations is not feasible. Retrofit of existing boats to improve capability has only limited feasibility for physical reasons.

3. Significant improvement of firefighting resources in many areas is not feasible due to long distances without substantial concentration of development. Stationing or attempting to assemble resources in such areas, such as along some reaches of the Mississippi, has no practical application.

4. In many, if not most, areas, including some ports, any risk from fire or from lack of adequate firefighting response capability will have to be accepted, unless local choice can provide for reducing the perceived risk.

5. Although cost effectiveness is not a concept applicable to firefighting in a given location, it is applicable to approaches chosen at the federal level. The Coast Guard Reserve Firefighting Coordinator training program appears to be one which should provide benefits in excess of its cost.

6. A significant problem in placement of resources for firefighting is the extreme rarity of fires and therefore unpredictability of place of occurrence.

7. Lack of appropriate information is a significant problem in attempting to estimate a balance of capabilities against types and sizes of fires. Statistical approaches generally do not appear relevant to the problem. A special survey of detailed reports generated from post-action debriefings of boat crews participating in firefighting of all types might provide some of the needed information, as well as be a data base from which more effective firefighting tactics might be developed.

8. Any further effort to study Coast Guard firefighting capability should be based on data from incidents that occur after inception of the study, and should therefore include a specially designed data reporting effort.

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FINAL REPORT

A STUDY OF PORT SAFETY FIREFIGHTING REQUIREMENTS

August 26, 1981

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16. Abstract

This is a report of an effort to characterize the firefighting capability needed by Captains of the Ports to respond to types and sizes of fires which might threaten port safety. Satisfactory results were not achieved because of lack of information needed for the relevant estimates. Port areas of Los Angeles, Houston, New Orleans, and Philadelphia were studied, with particular emphasis on Philadelphia and the Delaware River.

Within limitations of the study, U. S. Coast Guard Captains of the Ports were judged to have minor capability for single boat response to small fires and very weak capability against large fires, even using all available COTP capability. Other firefighting resources may not be dependable for various rational reasons. Municipal or other local waterborne firefighting capability may be declining due to cost and aging equipment. The feasibility of improving COTP firefighting response capabilities is limited because of size of area and response time, varied mission requirements, equipment limitations which physically limit improvements, manpower limitations, and cost.

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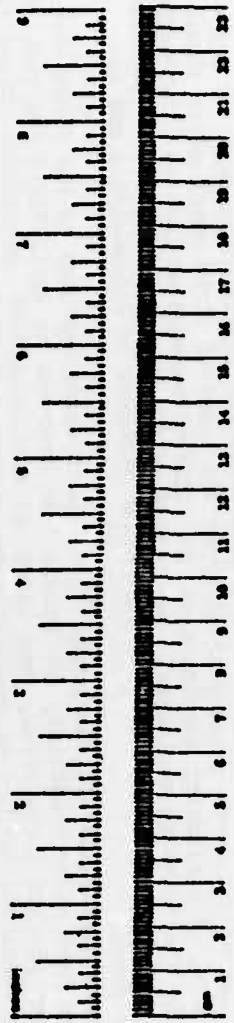
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

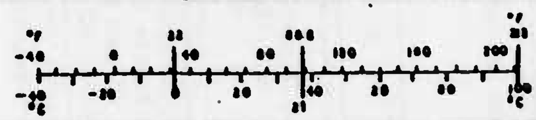
Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



A STUDY OF PORT SAFETY FIREFIGHTING REQUIREMENTS

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A STUDY OF PORT SAFETY FIREFIGHTING REQUIREMENTS

INTRODUCTION

This section provides a general discussion of the project and changes during its course. Difficulties encountered are mentioned as examples of negative aspects which might be avoided in future, similar projects.

This is a report of the findings of a project which resulted in limited if any positive success. Although the project may have been properly planned in its various stages, its success was dependent upon some necessary assumptions. The project plans were based upon availability of detailed information records, moderately static conditions of the subject being surveyed, and a manageable set of relatively similar locations. Both project personnel and the Coast Guard Technical Officer believed that the assumptions would be confirmed, at least to the degree that the project could be conducted as planned. However, the assumptions were erroneous, which led to two major changes from the initial plans. The altered plans were similarly unsuccessful for some of the same reasons. Because of these difficulties, the time required to consider and institute changes, and changes in USCG personnel, extreme delays occurred. Additional delay occurred because of novation of the original contract to another contractor. A typical

example involves a proposal for a change submitted in February. In July a response was received requesting some changes in the proposal. The proposal was revised and submitted in August. The modification was received the first week in October.

Initial Plans

This project was Task 4 of Contract DOT-CG-42,355A. The base contract was for studies of marine fire safety. Task 4 was entitled "Study of Port Security Firefighting Requirements." The initial concept of the Task was to attempt to characterize the kinds and sizes of firefighting that might be needed in the various Captain of the Port jurisdictions in the United States and to estimate the capability of the Captains of the Ports to respond to those needs.

It was assumed that the various jurisdictions could be roughly categorized into a few general port classes, based upon commodities, tonnage, traffic, and some geographic characteristics. As tentative classes, ports were expected to be exemplified by some selected, specific ports. On a geographic basis, ports might be coastal, like Los Angeles/Long Beach; they might represent in some respects the inland waterway complex, like Houston/Galveston; they might represent the river systems ports, like New Orleans; or they might represent the heavily industrialized ports of the river/bays of the eastern

seaboard, like Philadelphia. Great Lakes ports were assumed to be not significantly distinct from some combination of the other classes and therefore were not to be considered separately. The additional distinctions expected to affect the basic firefighting question were rather general, with the principal differences expected to be the result of trade levels and major commodities handled. It was expected that a real difference would be related to the trade and facilities for flammable liquid commodities (petrochemicals) compared to those for other commodities, essentially because of the potential for fire size and fire spread, both capable of developing rapidly. Although very large fires can develop fairly rapidly in combustible solids and explosions can occur in ore and grain facilities, a general assumption was that different responses would be needed for the two broad classes of materials. In ports with very large bulk flammable liquid complexes, it seemed probable that response capability for those vessels and facilities (as far as waterborne response is concerned) would also be adequate for controlling fires from the general cargo, lumber, grain, and ore trades. In ports with major shipping activities in Class A risks and firefighting resources designed for those risks, capability to respond to petrochemical fires might not be adequate.

The general approach expected to be productive in this initial effort was through a combination of study of

existing statistics on the selected port's operations and marine and waterfront fires, a study of reports on individual ship fires, particulary emphasizing those occurring in the jurisdictions of the Captains of the Ports of the selected ports, a brief survey of the resources of the Captains of the Ports, and interviews at various port agencies such as port authorities, fire departments, Coast Guard, and a few facilities. This information was to be supplemented by study of newsfilm and any available documentary film or photos showing ship firefighting, any available radio logs or recordings, logs of involved or participating vessels, and interviews with available boat crews and on-scene coordinators who had participated in firefighting. Three ship fires were selected for particular study: the Sansinea fire in Los Angeles and the Elias and Corinthos/Edgar M. Queeny fires in the Delaware River near Philadelphia.

It was generally agreed that the results of these procedures would not be statistically or technically representative, because the information sample had to be fortuitous rather than designed for the purpose. Nonetheless, it was expected that the results would not exhibit more characteristics of chance (or deviation) than would appear in a sample of all fires over three or four years. The results therefore should be analogous if not entirely representative.

In order to ensure a limit to the project if the plan or general approach appeared ineffective, we proposed that the project should be scheduled in two phases. We proposed that the project should be terminated if some initial activity (about thirty percent of the effort) indicated inadequate data or detail in the information or unrecognized weakness or lack of feasibility in the overall plan. Ultimately, we recommended exercise of that option. That recommendation was rejected in favor of alternative direction.

Phase I

The various subtasks of Phase I with brief comments regarding disposition of each are presented as follows:

Subtask A. Orientation discussions at USCG Headquarters, concentrating on six topics:

1. Clarify mission priorities of individual units in general. The highest priority mission is always search and rescue (SAR). Rare tasks for other agencies may have similarly high priority. Other mission tasks would ordinarily be abandoned to assist at marine emergencies such as fire or collision, but basically as a contribution to SAR. When vessels are available for secondary or backup response, tasks underway might be curtailed to provide that response. Generally, priority rank for missions other than SAR could not be defined.

2. Determine unit record-keeping practices. Detailed records of activities and equipment use for firefighting are not maintained. Brief reports are filed while task is in progress in form of Situation Reports. Radio logs provide some detail. Summary reports may be prepared by On-scene Coordinators. When marine boards are convened, testimony and evidence are presented, although rarely if ever on detailed aspects of firefighting. No formal post-emergency debriefings are done. Some details appear as background of marine board actions and in National Transportation Safety Board (NTSB) reports. NTSB reports are generally dependent upon Coast Guard investigation for all information upon which their findings are based.

3. Determine whether records in 2 are centrally located and available. The only central location of records was USCG Headquarters. Vessel Casualty Reports and Situation Reports were more or less available. However, access to those reports was only through the computerized casualty information system. Effective means of accessing those data were not found. Earlier types of reports such as Unusual Incident Reports from Captains of the Ports and Deficiency Improvement Reports were said to be available but extremely difficult to access and were considered to be an unproductive source. Although transcripts of marine board proceedings are probably available at Headquarters, availability and accessibility were not demonstrated.

Questions about these sources were generally ignored or passed over in discussions.

4. Discuss opinions about appropriate policy on undertaking or assisting in firefighting at major fires. Discuss opinions regarding refitting vessels with large capacity, high delivery-rate firefighting equipment, considering overall missions. Opinions on policy supported that expressed by Commandant Instruction. Opinion about the effect of that policy in practice was divided, with a minority admitting that practical necessity sometimes required significant divergence from policy in (a) taking overall command, (b) participating in significant firefighting activity even when considerable local resources were available, and (c) possibly taking risks excessive for the capabilities of boats and crews. Some admitted that stated policy may have had a negative effect on Coast Guard firefighting capability for those locations and situations where the Coast Guard is the only resource. Similarly, the policy may have a serious effect upon a unit commander's ability to acquire equipment to protect his crews: equipment such as masks, canisters, air packs, or adequate stocks of agents.

5. Assist in preparing a questionnaire to obtain information from field units. This item was deleted.

6. Determine the possibility of utilizing the pollution control strike force teams as a firefighting

strike force. Apart from a requirement for crosstraining and additional equipment, this appeared to be a potentially useful concept. However, utility is somewhat limited by relatively long response times and the necessity of using large aircraft for transport. Additionally, major fires which would be the most likely candidates for service are frequently sources of major pollution incidents. A single strike team could not assist in control of both events. Calling in a second team from another region would probably excessively weaken the limited backup capability now provided.

Subtask B involved analysis of potential fire sizes through visits to selected ports, interviews with crews and other COTP personnel, and study of all available reports, radio logs, and other information on fires, emphasizing those discussed with boat crews.

Subtask C involved estimates of relative firefighting capability of Coast Guard boats, based on their equipment, crews, and crew training.

Subtask D involved estimating capabilities that could be provided with boats in the current fleet. A conference at Coast Guard Headquarters was provided at the end of Subtask D to decide whether to proceed with Phase II.

Phase II

Phase II was planned to address the broader and more general questions of what firefighting responsibility and

firefighting capability the Coast Guard should provide. The question of acceptable responsibility was to be addressed in terms of technical feasibility at four levels: none; a level essentially as expressed in Coast Guard policy; primary level assistance or attack at any fires; and primary level services at fires where resources are limited, plus limited assistance to jurisdictions with resources, plus strike teams for primary level assistance at major fires.

Phase II also included estimates of capability of Coast Guard vessels to respond at the responsibility level recommended, recommendations for additions and changes, and recommendations for research which would provide or improve the capability to respond at the recommended levels.

At the conclusion of Phase I, the limited results were presented with the recommendation that the project be discontinued or at least deferred until better or more accessible information could be obtained.

Significant and specific types of information regarding numbers and types of marine casualties and detailed descriptions of firefighting responses to those casualties were not available, contrary to what had been expected when the original proposal for this task was prepared. Other deficiencies in available data, such as types of cargoes and vessels at risk, expected increases in traffic, and availability of assistance from other agencies, were pointed out. More significantly, we explained at

length the pseudo-technical nature of firefighting in general, particularly the absolute lack of any apparent direct cause-effect relationship between the kind of firefighting response and its effect on the fire. In general, successful fire control or fire extinguishment is achieved only by quantities of agents and methods of delivery which, compared to controlled fire extinguishment tests, would represent massive overkill. Coast Guard Captains of the Ports do not have, nor can they internally muster, such massive responses. In general, Coast Guard vessels which are able to respond first have too little pumping capability, too little maneuverability while pumping, too little foam agent, and too few crewmen to do much more than "show the flag." All of these characteristics, as well as the vessels' low-in-the-water aspect which radically affects both ship to ship agent delivery and boarding with handlines, appear to be unavoidable constraints of the multimission role these vessels and men must play in the overall objectives of the Coast Guard. Very important factors in firefighting capability are funding for both equipment and adequate manpower. These factors may be insurmountable.

Part of the recommendations offered regarding this project were related to timing. A number of projects funded by the USCG, MARAD, and perhaps other agencies appeared in the initial offerings (RFP's) to be of a nature that would

provide at least a portion of the desired information. We therefore suggested that within two to five years, a project of the nature originally envisioned might produce satisfactory and usable results. We indicated that achieving the desired results would require perhaps a two-year period, since it required not only finding, gathering, and assembling information, but perhaps also setting up a system for reporting some of the desired information. Consequently, we strongly urged the deferment of this particular endeavor for more propitious timing.

<u>Revised Task Plan</u>

The recommendation to terminate the project at the end of Phase I was rejected in favor of altering the objectives and scope of Phase II and to redirect efforts to the single port of Philadelphia.

The revised Task called for an attempt to (1) evaluate the hazards present in the port and expected fire sizes, types, and locations, (2) evaluate the firefighting capabilities of the port, and (3) recommend capability levels necessary for three levels of effectiveness against fires described by (1): extinguishment, control, or containment.

Extinguishment capability was specified as an ability to advance in a relatively short time with enough equipment and agents to rapidly control and virtually extinguish the fire well before all fuel was consumed.

Control capability was defined as the amassing of enough equipment and agents to prevent further spread of the fire area and gradually reduce the fire intensity until the fire was extinguished, again before all available fuel for the fire had been consumed. Containment represented the lowest degree of capability, and involved prevention of fire spread beyond its general location until all fuel for the fire was consumed and the fire went out or only scattered small fires remained to be extinguished.

Numerous delays occurred in work on the revised Task. Scheduling meetings for interviews was a continuing problem, particularly where the respondent was a volunteer firefighter or other official. Progress at interviews was slow because the general complexity of the problem required extensive explanation, even when the respondent had been provided beforehand with several typewritten pages characterizing the general nature of the project and the kinds of information sought. In a few instances of interviews with officials in the immediate Philadelphia area, it was difficult to maintain a particular perspective on the subject area. Many of these officials had been involved for several months in planning and in efforts to obtain federal funding to provide new fireboats for the area. Their efforts were joint with other states (i.e., New Jersey, Delaware, and Pennsylvania) and were supported by Congressmen proposing federal legislative remedies and by

other cities, states, and organizations supporting the legislation. This experience carried over into our interviews, to some degree even those with firefighters in other areas along the Delaware, and required frequent disassociation of this project from their earlier efforts, as well as a lot of backtracking to realign discussions with the current subject and purpose.

In a few instances, notably at the Wilmington, Delaware, Port Authority, officials were nearly non-responsive. There appeared to be a number of reasons for the apparent lack of interest: the organization has a small staff, all busy on other matters; we were unable to identify any individual likely to have some understanding of the subject; and an expressed doubt that a serious fire threat could occur in Wilmington. Because Wilmington has no marine fire response capability, problems elsewhere on the river were of no apparent concern.

The Task also continued to suffer from a dearth of records and from relatively rapid turnover of personnel at the COTP base, which drastically reduced access to first-hand accounts of Coast Guard firefighting experience in the port. Shift assignments affected accessibility not only of Coast Guardsmen but of volunteer and municipal firefighters. Fixed appointments frequently had to be sacrificed to the respondents' duties, particularly for interviews with emergency response agencies. City and port

officials also on occasion had to cancel or cut short interviews to answer an urgent summons from higher officials. Even when a deputy replaced someone in mid-interview, progress was very slow because of the need to begin the interview again with the background of the Task. In a typical instance, a Port Security Officer had to postpone an interview for three successive days, once to assist at a pollution case, once to assist a ship which had lost power, and once to assist at another unspecified ship emergency. On each day, the postponement was expected to be brief but lasted all afternoon. This interview was finally conducted with another officer who was not aware of the purpose of the interview and had no background information on the Task.

Discussions with a few industry representatives were with one notable exception less than fruitful. This may in fact have resulted from a tactical mistake of directly contacting the individual nominally responsible for fire prevention or firefighting activity at a facility, rather than requesting the cooperation of that individual through the executive levels of the company. The direct contact approach, citing referral by local acquaintances in the area, seemed to be one which would eliminate long, non-productive discussions and delays for decision at the executive level, and which would guarantee discussion with the local, knowledgeable individual rather than with some

distant director of safety. Unfortunately, discussions with the one responsive facility fire marshal (Frank Harrison, Manager of Property Conservation, Lavino Shipping Company) came late in the sequence. In retrospect, more direct intercession by such a congenial local individual might have improved the responsiveness of others. Despite the disappointing results in this case, direct contact with a knowledgeable local individual is still considered a better approach for the purposes than contact at corporate levels which results in an assignment to the local individual. Interviews or discussions set up on the indirect basis (through higher management) seemed to result in slower development of rapport, a tendency to reflect received opinion (the party line) rather than opinion based on direct observation and local experience, and a consequent longer period of discussion before frank exchange of opinions occurred.

The purpose of the preceding discussion has been not only to provide general background regarding this Task but to indicate types of problems encountered, so that future tasks of this type could attempt to avoid similar ones. The major problem throughout the Task was the assumption that for various good and logical purposes, certain types of information would be eminently useful, and that, therefore, the information probably would both exist and be accessible. Consider, for example, a major ship fire in a large port and

some purposes for which information about it might be collected. Obviously, it requires investigation to establish cause. A different investigating set involves establishing or eliminating aspects of negligence. Purposes of litigation constitute a third set. Economic recovery or just accounting of firefighting costs would seem to require a fourth set. As an item of local or national news interest, a fifth set might be generated. Still other purposes at the local level (such as historical or publicity) might generate still another set. In a few cases, personal interests of some individual such as a photographer might generate a set. Communications logs, time in service logs, and equipment use logs might generate a set. Given the fairly wide range of possible purposes, the original assumptions appeared fairly rational, not only to us and the technical officer but to many of the persons interviewed.

The second major problem was in scheduling. It was almost never possible to schedule discussions in a desired order or to fix the length of discussions to an expected time limit, and therefore it was rarely possible to plan for more than two interviews per day. Similarly, when appointments were delayed or canceled, it was rarely possible to fill the time with other satisfactorily productive activities. Very limited information was acquired by filling in with hastily arranged meetings with secondary sources.

As a consequence of such problems, results of the revised Phase II effort were not as satisfactory as expected. Another discussion of the project and its limited results was held in Washington. At this meeting, Coast Guard personnel suggested the possibility of redirection to attempt to provide a summary of basic firefighting contingency plan elements recommended for the Port of Philadelphia. A proposal to this effect was requested.

Although at the Washington meeting, it was believed the change in Task direction could be accommodated within remaining funds, a detailed estimate (and the proposal) indicated a requirement for an additional funding increment. Over the long period of time, the original funding level had been seriously eroded by increasing costs of inflation. The proposed increase in funding and Task redirection were rejected in favor of reporting available results. This is the subject of this report.

Organization of the Report

The report is organized generally along the lines of phases and changes, beginning with a brief review of an earlier, Coast Guard internal study of essentially the same problem. A selection of publications which were reviewed as sources for various project purposes is included, with the comment on each intended to indicate the purpose for which it was reviewed and some indication of its usefulness. That section is not intended to be a coherent review of state of

the art, but only of those items considered to need comment in sorting out their utility for various purposes. Accident reports are not included in the reviews.

PUBLICATIONS

"Manual for the Safe Handling of Flammable and Combustible Liquids," U. S. Coast Guard CG-174, is designed to emphasize preventive aspects, and therefore provides only a cursory description of equipment and agents that might be available on tank vessels.

The International Chamber of Shipping's Tanker Safety Guide: Petroleum (London, 1970) also emphasizes prevention. Chapter 9 is entitled "Fire Fighting" and gives a very general discussion of equipment, agents, and methods, limited to activities of the ship's crew.

The International Safety Guide for Oil Tankers and Terminals (London: International Chamber of Shipping, 1978) also provides brief general discussion only of "damage control"-type firefighting activities.

British Home Office Fire Department, Manual of Firemanship, Part 7: Fireboats and Ship Fires (London: HMSO, 1972). Although this publication is based mostly upon British organization, practices, and equipment, it provides such a detailed discussion of the subject that it should be a valuable manual for any organization involved in marine firefighting. Little of the value of the information presented is reduced by its British context.

Because this is one volume in a series of nine on the subject of "Firemanship," it has only limited discussion of very basic principles and of equipment, practices, and operations pertinent to ordinary structural firefighting or firefighting in general. Similarly, other volumes address the subjects of special occupancies such as aircraft or oil refineries and special hazards such as dust, metals, or chemical fires. This manual concentrates on the special subjects of fireboats and ship fires.

The manual consists of three chapters: Fireboats and Their Equipment, Seamanship and Firemanship, and Fires in Ships. Chapter Three, Fires in Ships, provides about a hundred pages specific to firefighting tasks. Fairly extensive discussions of ship construction and fire protection systems and the critical subject of stability and flooding are presented in the first three sections. Sections four and five discuss firefighting in port and at sea, and are particularly valuable in presenting brief descriptions of a great many tactics applicable to a broad range of fire types and situations. Almost all the operations discussed involve a boarding situation; vessel-to-vessel, non-boarding operations are not discussed. Facility firefighting from a water side vessel is also not discussed. Despite these two deficiencies, this manual provides the best general source for firefighters on how to attack a broad range of fire situations in ships, and in addition, provides generalized

information on equipment, seamanship, and navigation that should be useful to most crew members of vessels that may take part in firefighting activities.

National Fire Protection Association (NFPA) information on marine fires is primarily geared to prevention, and therefore has little application for purposes of response. Some standards provide specifications for fire control equipment. NFPA 302, Fire Protection Standard for Motor Craft (Pleasure and Commercial), 1972 edition, includes such specifications and about one page of vague discussion of operation of extinguishers. NFPA 303, Fire Protection Standard for Marinas and Boatyards, 1975 edition, and NFPA 306, Standard for the Control of Gas Hazards on Vessels to be Repaired, 1975 edition, have no practical application for response purposes. NFPA 312, Standard for Fire Protection of Vessels During Construction, Repair, and Lay-Up, 1976 edition, includes very brief comment on required preconnection of firefighting equipment and a warning statement regarding stability of vessels. NFPA 307, Recommendations for the Operation of Marine Terminals, 1967 edition, and NFPA 304L, Suggested Ordinance for Petroleum Wharves, are only advisory and do not relate to response actions. It should be noted, of course, that NFPA's efforts in the marine fire field are preventative, and properly do not address the subject of response. Further, many other NFPA publications apply to equipment for facilities,

vessels, and private and public fire brigades. The standards and recommendations specified in this brief discussion are those named as related to marine firefighting.

The NFPA publishes training films and hazardous materials guides and presents seminars on emergency response to hazardous materials accidents. These materials are generalized, and so, while useful, are non-ship-specific.

Various editions of the NFPA Fire Protection Handbook have included brief discussions of fireboats. The 1941 edition provided brief discussion on existing fireboat power plant types and pumping capacity and commented on use of small boats for under-pier and marina fires. The 1962 edition presented two pages, about half of which discussed recommendations or insurance underwriter requirements for major fireboats. Section 20 of the 1962 edition, "Marine," includes brief discussion of various preventive standards, specifications, and regulations, and a list of six texts on ship firefighting. The thirteenth edition (1969) mentions an NFPA pamphlet, "Fireboats," NFPA F-33-1, 1966, which was reported out of print. This pamphlet was not reviewed. This edition reported that some fireboats have been unable to legally respond to distress calls because they lacked proper papers for navigation outside an immediate area. The "Marine" section of this 1969 edition includes very little change from earlier editions. The fourteenth edition (1976, 1977) institutes a format change which introduces marine

fire hazards in the "Marine" section as well as the discussion of regulations, standards, and organizations contributing to marine fire safety that appeared in earlier editions. The separate discussion on fireboats is substantially unchanged from the 1962 and 1969 editions.

The Tanker Safety Guide (London: International Chamber of Shipping, 1970) concentrates on preventive and readiness aspects. A chapter on firefighting by the tanker's crew is included. The Guide provides only brief discussion of equipment and agents and typical uses of most.

The Fire Fighting Manual for Tank Vessels, U. S. Coast Guard CG-329, 1958, also is a familiarization manual for tanker crews. This manual is a useful introduction to theory, equipment, and agents. A chapter on fighting fires provides brief advice and precautions for attacking various classes of fires in various ship spaces. A generalized schematic more fully explaining the general principle of establishing boundaries of a fire area is included. The chapter on Case Histories of Tanker and Barge Fires and Explosions is in our judgment a very useful instructional tool. This manual is intended to illustrate damage control by the crew rather than firefighting attack by outside aid, and addresses controlling smaller fires from the ship. It offers no useful information on how to attack the fire from another vessel or how to control the fire from an external station in order to achieve boarding.

The National Fire Protection Association's "Guides for Fighting Fires in and Around Petroleum Storage Tanks" (NFPA SPP-31) is a reprint of a guide originally prepared by the American Petroleum Institute in 1974 (API Publication 2021). The Guide includes some precautions and general guidelines which might be included in training, particularly in that supplied for the USCG Reserve Firefighter rating.

Some older but not necessarily outdated information is presented in a book by a British Firemaster and former London borough Chief Officer, Frank Rushbrook, entitled Fire Aboard (London: Technical Press, Ltd., 1961). This book is a fairly extensive discussion of problems of prevention and control of fires in ships and port installations. Sections on Fire Fighting in Port; Some Principles of Fire Fighting; and Fire in Oil Tankers are most relevant. Much emphasis is placed on prevention and preparedness. A recurring theme of this author is the recommendation for a single chain of command and a single authority in charge of response to a fire emergency. He recommends close personal liaison among various authorities likely to be involved as a means of implementing the command structure when needed. He also recommends that lower ranks should be encouraged to visit principal ships using the port as well as become familiar with facilities. Fire Aboard would be more useful at command levels than to the ordinary seaman or fireman.

A brief report entitled "First Report of Working Party on Incidents in Ships in Docks and Ports" was issued in May, 1976, by the British Joint Committee on Fire Brigade Operations of the Central Fire Brigades Advisory Council for England, Wales, and Scotland. The Report concentrates on general principles of port liaison and other matters of a strategic nature. The report recommends formal liaison committees with special study groups, preparation of emergency response plans, and regular exercise of the plan or parts of the plan, not less than annually. Communications plans and preplanning, including familiarization with shipping layouts are particularly emphasized. The Report includes some statistics from a 1949 study and some developed for the 1976 Report, and reaffirms most of the conclusions regarding causes from the 1949 report.

Chapter 93 of the U. S. Navy Bureau of Ships Manual, entitled "Fire Fighting - Ship," is essentially a damage control manual for firefighters. It is directed towards firefighting by the ship's crew, and assumes a fairly large crew with a well-trained firefighting contingent. Some of the most pertinent material from this manual is incorporated in various Coast Guard training programs, particularly for the Damage Controlman and Port Security ratings. More of the manual is used in the Reserve training for the Firefighter rating. Procedures for accomplishing boarding for firefighting or vessel-to-vessel or vessel-to-facility firefighting are not discussed in this Chapter.

A series of reports which reasonably could have been expected to be useful for contingency planning for response to waterfront and other high-hazard area emergencies was produced over an eight-year period (through 1975) by the New York City Rand Institute. The Institute developed a system of models and methods to evaluate and improve deployment of emergency services. Over thirty reports and several computer models, by the National Service Foundation, the U. S. Department of Housing and Urban Development, and others, were produced. Typical titles include, "A Simulation Model of the New York City Fire Department: Its Use in Deployment Analysis;" "Deployment Methodology for Fire Departments;" and "Improving the Deployment of New York City Fire Companies." Of more direct interest for this report were two reports, "An Analysis of the Deployment of Fire Fighting Resources in Trenton, New Jersey" and "An Analysis of the Deployment of Fire Fighting Resources in Wilmington, Delaware." While these reports and methods are probably useful for automating some of the traditional procedures for selection of locations for emergency response facilities and may even predict methods and locations which result in higher efficiency at lower cost, the methods are ultimately dependent upon a data base for success. For purposes related to port firefighting, the demonstration reports for Trenton and Wilmington are useless because no hazard or hazard level is identified, and no port facilities, special

hazards, or potential response requirements are identified. Consequently, for the Wilmington case in particular, port firefighting response capability might be degraded rather than improved by the recommended changes.

The "Multipurpose Harbor Service Craft Requirements Study" prepared by the City of Tacoma, Washington under Contract No. 3-36268 for the U. S. Maritime Administration (Report Nos. MA-RD-900-74044 and MA-RD-900-74045, February, 1974) developed performance requirements for a vessel suitable for service in marine firefighting and harbor law enforcement, rescue, and pollution control.

Although this report examined potential non-firefighting functions in its effort to achieve a multi-mission design, it did not reexamine the marine firefighting task or the firefighting equipment requirements traditionally recommended. The principal difference between peformance of customary fireboats and that recommended by the Tacoma study is tied to hull design: a 30-knot, low-wake, shallow-draft configuration is desired. Automation to allow a crew of only 2 to operate the boat is available on some existing boats and so is not a unique requirement. Consequently, although the study is useful for other cities or ports with similar fireboat needs, it did not provide basic, minimal design data which would have been so useful for our study.

"Marine Fire Fighting," by J. J. McCauley is a pamphlet published in 1979 by Flame Press of Miami, Florida.

About 25 of the 55 pages of this pamphlet provide a general discussion of planning, response activites, and potential problems for the case of an inbound general cargo or passenger vessel with fire aboard. Ten pages are general comment on the problems of fire at sea, including fire on oil and LNG tankers. The discussion includes the usual misconception that "all USCG District Offices have access to the most modern equipment and supplies for shipboard fire-fighting. Their crews all have extensive fire and damage control [experience] in ship fires." Six pages discuss fireboats, emphasizing use of smaller boats and the decline in availability of fireboats. The remaining pages discuss fires at piers and wharves and at marinas, emphasizing the importance of proper construction and installed fire protection systems. The pamphlet provides little useful information, although it could be useful as a public information source to increase public understanding of the nature of the marine firefighting task.

<u>Contingency Plans</u>

Contingency planning documents appear to be more readily available for natural disaster response, nuclear accident response, and pollution response than for other types of incidents. Most such documents include very limited subsections related to control of fires. Nonetheless, some of the documents may have value as examples of general organization of response at various levels, for

identification of resources at local, state, and federal levels, and for guidance where the primary response of fire-fighting is complicated by necessity for pollution control, evacuation, or other types of response occasioned by natural disasters.

The "National Oil and Hazardous Substances Pollution Plan" was issued by the Council on Environmental Quality as Part 1510 of Chapter V, Title 40, of the Code of Federal Regulations. The Plan was revised in February, 1975. The Plan is essentially a regulation mandating and enabling the establishment of a national-level response organization, regional organization, and interfaces with local organization. The Plan is useful in delineating national and regional advisory bodies and establishing permissible interactions of Federal agencies. With the exception of some technical definitions and mandatory test specifications, the Plan provides no detail useful at the field level. Emphasizing pollution countermeasures, it provides little specific reference to the firefighting task.

Considerably more useful guidance is provided by "A Suggested Development Plan for a Regional Contingency Plan Data Base" (USCG COMDTINST M 16466.1, June, 1978). This Instruction provides a tested method of acquiring and organizing information about response resources and characteristics of facilities. Although the major thrust of this document is for pollution control, the majority of the data

collected should also apply to major fire events, particularly fires involving flammable liquids in bulk. The Instruction provides extremely useful sources for maps, data on streams, and directories. A number of data collection techniques and samples of forms for organizing data are provided. Where the data have been acquired and assembled in accordance with this Instruction, the basic resources for firefighting should be included. The means and mechanism for assembling those resources is not discussed. In addition, the procedure outlined only catalogs the resources; it does not assure availability.

A method of organization of Coast Guard pollution control response at regional to local COTP level is provided by "Contingency Planning for Pollution Incidents, (USCG COMDTINST 16465.10, March 1978). The Instruction provides for organization along functional lines. Consequently, the Instruction is not generally applicable to the firefighting task, although much of the functional structure could be used as an example for organizing firefighting response.

F. C. Gunderlog and W. L. Stone's "A Guide and Checklist for the Preparation of Contingency Plans" is Volume 2 of "Manual for the Control of Hazardous Spills" prepared by Rockwell International under Contract No. 68-03-2648 for the Environmental Protection Agency's Municipal Environmental Research Laboratory--Cincinnati. This is a generalized tutorial guide written in informal

style. It is probably useful in providing lists which can act as reminders, in pointing out a few problems that can occur in planning, and in its emphasis on the contingency plan as a tool to achieve effective response readiness. Critque and revision of the plan; training exercizes and critique; and post-emergency-response critique are emphasized, all with the admonition for follow-up revision of plans or operations. The Guide may imply simpler access to legislative remedy and federal or state assistance funds than in fact is feasible. However, the Guide properly includes emphasis on desirability of preparing rather than copying a plan; on ensuring the factual availability of promised resources; on frequent training; on critiquing responses, training exercises, and the plan itself; and on revising and updating the plan to correct observed weaknesses and keep information current.

A report issued by the National Academy of Sciences in 1979 included some observations similar to those of this report. The report was prepared by a Panel on Response to Casualties Involving Ship-Borne Hazardous Cargoes of the Marine Board, Assembly of Engineering, National Research Council, and was supported by the U. S. Coast Guard, Army Corps. of Engineers, Maritime Administration, and the U. S. Navy through Office of Naval Research Contract N00014-77-C-0796. The report was entitled "Responding to Casualties of Ships Bearing Hazardous Cargoes."

The Panel used a game simulation study approach in four stages:

1. Information gathering and review;
2. Outlining a number of plausible casualty scenarios;
3. Conducting seminar workshops to identify capabilities and deficiencies in equipment, personnel, and procedures for responding to the plausible casualties; and
4. Preparing a report identifying deficiencies in equipment and personnel and recommending programs to alleviate deficiencies.

The information gathering and review stage produced several notable comments:

1. Only 17 of the 460 commercial ports in the U. S., which includes some 80 ocean ports, maintain any marine firefighting capability.
2. Marine firefighting assets are often being sharply cut back because of limited local funds.
3. Marine firefighting is not well coordinated with land firefighting and disaster response efforts, even where contingency plans exist.
4. The risk of serious marine fires is increased by the trend to relocate bulk cargo facilities to areas which may not have the tax base to support adequate response capability.
5. Technical information on vessels and cargoes is not readily available.

6. When more than one agency is closely involved in response, there is an urgent need to establish operational liaison at the earliest practicable time.

7. Contingency planning is effective only to the extent that it is understood and relied upon in the field. The best way to ensure field-level familiarity with a contingency plan is to exercise it periodically.

8. Lists of equipment and agents and local contact persons are not always available in local disaster plans.

9. After initial notification of the occurrence of a marine casualty, "communications problems may begin in earnest." Lack of commonly held frequencies for emergency use (and appropriate equipment) overloads available systems, contributes to lack of coordination in the response, and limits the possibilities for backup systems if primary systems are damaged.

10. Technical and legal constraints affecting the marine salvage industry may affect response operations or at least the operational options available.

Although the Panel used somewhat unconventional methodology, their identification of firefighting deficiencies corresponds with deficiencies noted by other groups who used statistical and case study methods. One weakness of the report is its failure at times to document the association between the games and some of the conclusions. As an example, the effectiveness and competence of the

Office of Emergency Services of the State of California are highly praised. That conclusion is difficult to deduce from the narrative and discussion of the California game.

With minor alterations, the methodology used by the Panel would be an excellent method for exercising command and coordination functions of contingency plans.

Four port contingency plans for dealing with the somewhat specialized problem of liquefied gas terminals and tankers were examined. Since these plans are modified from time to time, the versions reviewed may not be the most recent. The four plans reviewed were the "LPG Contingency Plan" issued by MSO, Corpus Christi, Texas, 11 April 1979 for the Ports of Corpus Christi and Port Lavaca; the "LNG/LPG Contingency Plan" issued by COTP, Providence, Rhode Island, 1 August 1975, with Change 1 dated 25 April 1977; the "LNG-LPG Operation/Emergency Plan" issued by MSO, Boston, Massachusetts, 7 September 1978 and Amendment One dated 18 December 1978; and the "Fifth Coast Guard District Liquefied Natural Gas Emergency Contingency Plan" dated 19 May 1978, for emergencies in the Fifth District, nominally Cove Point, Maryland, and Hampton Roads, Virginia.

The three port plans include both information on response to emergencies and information related to specialized requirements for movements and operations of these vessels. The Corpus Christi plan, for example, includes much regulatory information, requirements, and

specifications related to safe construction and operations, all of which should be available in more detail in other documentation. Moderate detail on emergency actions and notification (phone lists) is provided. A short section of excerpts from published LNG/LPG fire response guidelines is included.

The Providence plan is quite similar to the Corpus Christi plan. It includes a similar section incorporating excerpts from technical firefighting literature. One required response action is to review those materials with stand-by boat crews (after initial boats are dispatched). That step in the response sequence is probably a useful one. The Providence plan also includes data tables and curves from the Chemical Hazards Response Information System (CHRIS) to assist in determining extent (distance) and degree of hazards.

The Boston plan supplies more local notification numbers, but less detail on response activities and no explicit precautionary advice for crews or data for estimating hazard.

The Fifth District Plan is specifically directed towards emergency response. It is organized in parts to (1) identify the general nature of the emergency; (2) identify response activities appropriate for the type of emergency; and (3) hazard assessment tables and graphs. The District Plan is about three times as long as the other

plans, partly because a separate response plan is provided for each of the ten identified emergency types. Local notification networks are not included. The format of the plan should make it easier to use. Appendices provide hazard assessment tools and very general data on the vessels expected to be involved in the emergency types.

Two reports which are unrelated to a marine or fire incident were examined. These were reports discussing some aspects of the emergency which occurred at the Three Mile Island nuclear plant southeast of Harrisburg, Pennsylvania, on March 28, 1979. The reports examined were prepared by the staff of the Presidents' Commission on the Accident at Three Mile Island. They were "Reports of the Office of Chief Counsel on Emergency Preparedness, Emergency Response," October, 1979; and "Report of the Emergency Preparedness and Response Task Force," October, 1979. These documents were examined because they are in reference to (1) plans which had existed, in some cases, for a number of years; (2) plans in an industry and activity which historically has been constrained to high levels of technical accountability through detailed analysis and documentation; (3) plans which were activated in response to a real emergency; and (4) plans which were examined in-depth after the emergency, an examination of how effectively the plans had produced desirable and effective response.

These reports could serve two purposes: they provide detailed accounts of the types of problems involved in implementing plans; and they provide some general guidelines or criteria which appear suitable for assessing the adequacies of emergency response plans and the adequacies of the response they produce. Some of the criteria of adequate response are equally applicable to marine fire emergencies, particularly those which could affect populations at a distance.

1. Prompt notification of public authorities.
2. Activation of public warning (which evokes appropriate citizen behavior toward preventative actions, such as evacuation).
3. Collection and consolidation of information concerning threat and impact.
4. The translation of information into task responsibilities for emergency organizations.
5. The coordination of the response of the various emergency organizations.
6. The establishment of emergency operations centers.
7. The distribution of public information.
8. The establishment of mass care facilities.
9. The containment of threat.
10. Search and rescue.
11. Provision of emergency medical services.
12. Incorporation of volunteers into on-going emergency organizations.

A similar critique of effectiveness of response to emergencies was prepared by the National Transportation Safety Board in "Special Investigation Report: Onscene Coordination Among Agencies at Hazardous Materials Accidents," (Washington, NTSB-HZM-79-3, September 13, 1979). This reort examined a single railroad accident. Deficiencies in the response produced by the applicable contingency plans were suspected to be deficiencies common to plans for other types of emergencies:

1. Lack of command of the accident response.
2. Lack of coordination of effort.
3. Deficient communications.
4. Lack of a command post.
5. Poor control of access to the accident site.

As an individual case review, this report is informative. In this case, existing plans did not provide guidance for the deficiencies noted.

Of the contingency plans reviewed for this project, only one was specifically on the subject. This plan is the "Burning Ship Contingency Plan," issued by the Captain of the Port, Portland, Oregon, 31 December 1979. This plan emphasizes the role of the COTP, with only brief mention of interaction with and responsibility of other agencies. The plan format appears to be an effective one. The plan provides extensive lists of resources available, with the single exception of a direct relationship with medical

resources. This resource is probably provided through the County-level emergency response network, which is detailed in the plan. Thirty-one pages of blank data collection forms are included, all of which appear useful as a check-list at various stages of response. Instructions on use of the forms is provided. Since the plan is essentially guid-ance for the COTP response, it contains no guidance of overall coordination and no reference to plans prepared by other agencies. For its purpose, however, it is an admir-able effort, particularly if it is periodically reviewed, updated, and critiqued after use. It contains no provision for periodic exercizes as a training and coordination activity.

Comments on a Cost-Effectiveness Study

In 1978, SRI International produced for the U. S. Maritime Administration a report entitled "Cost Effectivness of Marine Fire Protection Programs." Although the report suffers from a number of misconceptions as well as a shortage of historical data, it may have limited utility for illustrating value received for training funds spent under various alternatives. As an indication of the type of defi-ciencies in the design of the study, cost-effectiveness is essentially defined as the largest annual net savings (reduction in loss), rather than as largest annual return per dollar spent. The combination of alternatives SRI defines as "optimal" consists of a combination of five of

the eight alternatives considered. A total of twelve combinations was tried, with the combinations ranked by the result of the calculation (Reduction in loss - Increase in Cost) = Net Savings. The optimal combination produced $28,100,000 Reduction in Loss at a Cost of $4,500,000 for Net Savings of $23,600,000. Using SRI's reasoning, if another alternative produced $528,100,000 reduction in loss at a cost of $504,400,000 for a net savings of $23,700,000, that would have been the optimum combination. The basic flaw in the reasoning is that it disregards what is obtained for each dollar spent. In the first case, each dollar spent produces $6.24 reduction in loss; in the second case, each dollar spent produces about $1.05 reduction in loss. The following tabulation, with two new columns added, illustrates the effect of SRI's analysis.

COST-EFFECTIVENESS OF SELECTED COMBINATIONS OF ALTERNATIVES

(Millions of Dollars per Year)

SRI RANKING	REDUCTION IN LOSS	INCREASE IN COST	NET SAVINGS	$ REDUCTION PER $ SPENT	ATC RANKING
OPTIMAL	28.1	4.5	23.6	6.24	5
2	27.5	4.0	23.5	6.87	3
3	25.9	3.8	22.1	6.82	4
4	27.5	7.2	20.3	3.82	10
5	22.1	2.5	19.6	8.84	1
6	25.0	6.5	18.5	3.85	9
7	20.2	2.3	17.9	8.78	2
8	22.0	5.2	16.8	4.23	8
9	11.0	2.0	9.0	5.50	7
10	10.1	1.7	8.4	5.94	6

Unfortunately, SRI apparently did not try a simple combination which produces a higher net savings and a significantly higher return on a dollar spent. This combination consists of low-level fire department training, mandatory installation of spray collars in engine rooms, and the so-called Coast Guard Reserve Plan, which would provide special trained reserve units to act as on-scene advisors at marine fires.

	$ Saved	$ Cost	Net $ Saved		$ Saved Per $ Cost
F. D. Tng	7.2	0.323	6.877		22.29
Collars	3.3	0.158	3.142		20.89
USCGR	15.1	1.040	14.060		14.52
Totals	25.6	1.521	24.079	AVG.	$16.84

Thus a higher net savings ($24.08 million vs $23.6 million) could be achieved at one-third the cost ($1.52 million vs $4.5 million) with a significantly greater return on dollars spent ($16.84 vs $6.24 per dollar spent). Taking the general SRI discussion of the subject at face value, the assumptions used in the re-analysis of the data would produce results no less reliable than the original results.

The second general assumption in the SRI report is that the effect of firefighting training would appear equally in any kind of marine fire; and, an unexpressed but apparent assumption, the firefighting training would be geared to land operations or operations involving boarding the burning vessel. For certain initial damage levels, as

defined, the assumptions are valid: these are the obvious small fires and moderate fires in spaces or superstructure, with a few categories of open tank fires, and the less obvious catastrophic fires of the magnitude of Texas City. The problem in the assumptions is that they inherently imply some degree of effectiveness over a much greater range of fire severities and loss conditions than is appropriate. The result is an implication that the proposed measures will have effect on a larger portion of the total population of fires than in fact would be affected. None of the alternatives proposed could have much effect on ship fires where boarding is not possible, except the catastrophic level, where shore fires are the greatest problem. Of several ship fires specifically mentioned (though not in this context), the Elias, the Sansinea, the Corinthos, and the Sea Witch, none was boardable or could have been managed better as a result of the proposed programs. The report also apparently includes losses from the Corinthos among losses that might have been partly averted with training such as that proposed; in fact, training would not have reduced the losses, because the ship was allowed to burn under control without attempting complete extinguishment.

The point of this discussion is to emphasize that notwithstanding the obvious problems with the SRI report, based on SRI's data the proposed Coast Guard Reserve firefighting advisor program has much more potential for reducing losses than it has been credited with in the past.

TWO PREVIOUS STUDIES OF COAST GUARD FIREFIGHTING CAPABILITY

The Morgan Report, 1965

The subject of Coast Guard firefighting capability was examined in April, 1965, by a special committee at Coast Guard Headquarters in the "Report of the Working Group on Interstate Transportation of Dangerous Cargo." This report became known as the "Morgan Report," after the group's chairman, Captain Harry Morgan. The Morgan Report was Phase II of the Working Group's study; Phase I, chaired by Captain Huston, was completed in May, 1964.

We were unable to determine whether the working group issued full technical reports on its activities or only a memorandum (with endorsements) to the Commandant. At least one memorandum and endorsements were included in a Coast Guard report, "The Role of the Coast Guard in Ports and Waterways Management and Administration," July 1971.

The Morgan report was concerned with the overall issue of interstate transportation of dangerous cargo. However, a significant proportion of its discussion was either directly or indirectly related to the question of firefighting capability. Of eleven recommendations forwarded by the Group, three directly concerned improved firefighting capability through (1) improvements in

equipment, (2) stockpiling firefighting agents in strategic locations, and (3) developing emergency response plans.

The Morgan Report's findings and recommendations for improved firefighting capability were based on reports requested from five Districts, vists to four ports, and discussions with Captain of the Port personnel from major eastern ports. Discussion with local firefighting forces along the Inland Waterway System was mentioned. Some correspondence and discussion passed between the Working Group and the Offices of Engineering and Operations.

No copies of reports on Phase I work were seen. In addition, none of the original data assembled by the Working Group could be located, although at least the "Collected Data on Field Firefighting Capability" was originally appended to the final report (Phase II) of April 30, 1965.

The endorsement of the Office of Engineering on the Morgan Report indicated in some respects a different source expressing concern about firefighting capability. In May, 1964, perhaps in relation to Phase I of the Working Group's activities, Naval Engineering Division had prepared an informal report on visits to and discussions with fireboat personnel and marine fire chiefs at four major port cities and Washington, D.C. This report could not be found. In June, 1964, Engineering was asked by Operations to consider the feasibility of providing COTP utility craft a minimum pumping capability of 200 gpm at 100 psi. Engineering's

endorsement to the Morgan Report indicated that the suggested capacity was inadequate. "Further investigation and discussion indicate that the following minimum capability might be preferable to fill the operational needs of the COTP units:

(1) Installed fire pump - 500 gpm at 150 psi for boats 65 feet and under. Capacity of 1,000 gpm at 150 psi for boats over 65 feet.

(2) Installed foam tank.

(3) 200 feet of 1-1/2 inch hose. . . .for boats under 100 feet. Boats over 100 feet. . . .200 feet of 2-1/2 inch hose. . . ."

As with other information which might have been quite useful, no more information on the "further investigation and discussion" could be found. Of particular interest, of course, was the basis for the recommendation of much higher pumping capacity at higher pressure. Was there an engineering basis or was it just a good idea?

The Working Group report and its recommendations were approved in November, 1965. The recommendation for the unspecified improvements in firefighting capacity was to be implemented by Engineering, "within budgetary and operational limits."

<u>The Role of the Coast Guard in Ports and Waterways Management and Administration</u>, 1971.

This report identified five fruitful mission areas, one of which was firefighting/prevention. The methods of the firefighting/prevention study group were quite similar

to those planned for this report, with an apparent difference that the 1971 Coast Guard study group relied more heavily on statistical data. The study group concentrated on assessing risks and trends of waterfront and marine fires, the adequacy of Coast Guard and/or other fire fighting capabilities, and recommendations for Coast Guard improvement in preventing and fighting waterfront and marine fires in the ports and waterways.

The firefighting study group examined a considerable amount of information, both statistical and qualitative:

(1) The Morgan Report.

(2) Assistance Reports, FY 1967, 1968, 1969 - all cases where Coast Guard participated in firefighting.

(3) Deficiency Improvement Reports, FY 1967, 1968, 1969 - all instances of unsatisfactory equipment or personnel performance.

(4) All COTP Unusual Occurrence Reports, FY 1967, 1968, 1969.

(5) Boating Statistics, FY 1966, 1967, 1968 - all recreational boating fires.

(6) Merchant vessel casualties from fires, FY 1969.

(7) Questionnaires to selected Captains of the Ports to assess the firefighting/prevention situation in their areas.

(8) Questionnaires to all District Commanders to determine their opinions of then-current Coast Guard policy for waterfront/marine firefighting and prevention and suggestions for improvements.

The results of the Working Group's "Morgan Report" and of the Ports and Waterways study indicated inadequacies in pumping capacity, in foam firefighting agent supplies, in

availability of personnel protective equipment such as masks and replacement canisters, and in some items of firefighting equipment hardware such as nozzles and hose. The Morgan Report and its endorsements indicated a slightly greater concern with pumps and, to a degree, boats and training. The Ports and Waterways study mentioned relocation of some boats with better firefighting capability to ports with higher fire risk than that of their present location. Perhaps because the Ports and Waterways study had a broader scope than just firefighting, considerable emphasis was placed on improved fire prevention and legislation or regulation to make the self-help firefighting capabilities of both facilities and carriers (vessels) adequate to control fires from their operations or cargoes.

Both reports found the Commandant's current firefighting policy adequate. Minor changes in the policy were written after the Morgan Report. Additional minor changes in the policy were made after the Ports and Waterways study. Both reports implied or expressed the delicate line of distinction that makes the policy satisfactory in one respect and inadequate in another. That distinction is in how to determine or establish firefighting capability adequate to allow safe operations of Coast Guard vessels and facilities without providing a capability and service that will affect local willingness and commitment to maintain adequate local firefighting capability. Both

reports mentioned the problem of long reaches of waterborne commerce where there are no local resources or communities to provide them. Both commented that public opinion expects the Coast Guard to participate in marine and waterfront fire fighting, even in some cases expecting the Coast Guard to be "the prime firefighting agency afloat."

Direct detailed comparison of the results of these older studies and those of this present report was not possible because the original documentation could not be located; only the summary reports were available. It is apparent from the summaries that information obtained at the executive levels of District Commander or Captain of the Port may lack needed detail of deficiencies; may emphasize final overall results of firefighting efforts while overlooking difficulties encountered progressing towards those results; and may indicate optimism more reflective of attitude than practical experience. This could explain why policy is considered adequate, but "additional equipment, better training, and improved regulations are necessary for an effective program."

BRIEF DISCUSSION OF CHARACTERISTICS OF SELECTED PORTS

Under Phase I of this project, a number of ports, each representing some characteristics of the total ports and waterways system, were to be selected for visit and discussion. Although all selected ports were to be large ones with a resident Captain of the Port, they could not represent the characteristics of every port in the nation. After discussion at Coast Guard Headquarters and with the Technical Officer, four ports were selected: Los Angeles/Long Beach; Houston; New Orleans; and Philadelphia. They were chosen to represent a mix of both high and low hazard commodities and a range of geographical characteristics. Los Angeles/Long Beach represented a coastal port; Houston the high-hazard, congested waterway; New Orleans the inland river system; and Philadelphia the inland river/bay type, highly industrialized eastern seaboard port.

<u>Los Angeles/Long Beach</u>

The Los Angeles/Long Beach Captain of the Port area is somewhat distinct from the other selected ports in that the ports proper are separated from open ocean only by breakwaters. Consequently, the possibility of a necessity for firefighting activities at sea appears somewhat higher. Although some of the same types of incidents might occur in

the Gulf areas, in those areas the offshore oil activities should offer more resources to assist. In addition, as far as the Houston COTP is concerned, a lot of his operational area is in protected waters, allowing assistance from less seaworthy resources. The Los Angeles COTP can only rely on such assistance behind the breakwater. Beyond it, any assistance to Coast Guard resources must come from commercial sources. This limitation on resources is because of the design of the Los Angeles fireboats. Regardless of whether the municipality would be willing to aid at distant locations, the boats rarely venture beyond the breakwater, and certainly never far from the shoreline, principally because of the probability of the boats capsizing even in moderate seas.

The Los Angeles/Long Beach Port handles a broad-ranging mix of cargo, from general cargo, scrap metal, automobiles, and food commodities to petrochemicals including liquefied propane. Los Angeles/Long Beach is a very active port, but, because of its physical location it is not complicated by long reaches of congested waterway as in the other selected ports. Incidents of all types such as grounding and collision do not appear to cluster at separate locations. Only at the ship lanes converging at the breakwater and in the immediate area of the shoreside facilities does there appear the congestion plaguing other ports. Consequently, fire accidents are most likely to occur well

within the operational area of the Los Angeles fireboats. One complicating factor more apparent in the Los Angeles/Long Beach area is the existence of large marinas crowded with concentrated, high-value, small private vessels. These areas are considered somewhat risky by the Fire Departments because of difficult access by fireboat or by land units.

Of the ports visited, only at Los Angeles was it reported that the Coast Guard "never" participated in in-port firefighting. Although there were a few occasions when some firefighting activity occurred, notably at the Sansinea fire, the occasions are so rare that they approach chance encounters. Fires outside the port are almost as rare.

The Los Angeles/Long Beach harbors lie in a semicircle about 19 to 20 miles long. Port Safety personnel of the COTP consider roughly one third of the industrial waterfront space to constitute a moderate fire hazard. Eight locations spaced about equidistant around the perimeter of the conjoined harbors are considered of high hazard. The area of the high hazard facilities is comparatively small, with the Catalina Terminal the largest, occupying a roughly square plot, each side of which is slightly over 1000 feet long.

There appear to be a number of factors which affect the low firefighting response rate of Coast Guard boats.

The port has the appearance of a somewhat better layout than other ports visited. Facilities appear to be either newer or better maintained. Refineries and tank farms are less concentrated and, compared to some in other ports, have less the appearance of cluttered collections of rusty junk. While appearances may be meaningless, they may on the other hand indicate a better attitude towards fire safety. Such an attitude may also be reflected in an apparent readiness to call for standby assistance even for minor problems like a small fuel spill in a small boat.

The principal reason for the Coast Guard's low firefighting activity in this port is the Los Angeles Fire Department. The Department is widely recognized as one of the most effective in the nation. For marine and waterfront firefighting, Los Angeles operates five fireboats located roughly equidistant around the harbor. Three of the boats are 35-foot boats with almost 30-knot speed capability and a 750 gpm, 150 psi pump capacity. These boats have a crew of three men and carry 50 gal of foam concentrate and 15 gal of light water. These boats have primary functions of fire-fighting and rescue in the marinas. The boats are about 13 years old.

Fireboat 2 is 100 feet long and has a top speed (with large wake) of 14 knots. Pump capacity is 10,000 gpm at 150 psi. This boat carries 500 gal of foam concentrate, 75 gal of light water, and 800 lbs of carbon dioxide. The

crew consists of five seamen and three firefighters. Under Los Angeles' Task Force concept, engine company firefighters at the same station may respond on the boat, adding five personnel to the crew. This boat has high-mounted monitors with up to six-inch tips, low-mounted, under-pier monitors, maneuvering jets, and a 30-foot above-waterline hydraulic boom. The boat was completely rebuilt in 1970.

Fireboat 4 is 76 feet long and has a top speed of 12 knots. Pump capacity is 9000 gpm at 150 psi. The boat carries 500 gal of foam concentrate and 75 gal of light water. This boat carries a crew of five and two firefighters. This boat has waterline maneuvering jets and low-mounted monitors. Both large boats carry specialized equipment designed to be used by SCUBA divers for underwharf fires. This boat also operates on the Task Force concept to add personnel. Fireboat 4 was built in 1962.

Under normal operating procedures, a boat and its resident engine company respond to each alarm. When the Task Force concept is in effect, additional land companies respond.

Additional resources for the remainder of the harbor are supplied by the Long Beach Fire Department. That Department operates three strategically located fireboats. Two are 58-foot fireboats of typical design, with a pumping capacity of 4500 gpm at 150 psi. Long Beach also has a 36-foot catamaran fireboat for response at higher speed.

The concept of mutual aid agreements is essentially unnecessary in this area because of a state law which provides a Master Mutual Aid Plan which takes effect upon "condition of local peril." Notification of that condition may be transmitted directly to a neighboring city or through the Los Angeles County Office of Emergency Services. Los Angeles City Fire Department rarely requires outside aid for marine or waterfront fires. Long Beach sometimes may require assistance, and sometimes relies upon local refineries and other industry to assist with equipment or supplies. Personnel of both Departments have general knowledge of local industry's stocks of foam as well as their firefighting equipment.

The resources available to the Captain of the Port were considered to be adequate by COTP personnel. We are in agreement with that judgment, based on the low level of activity within the port and on the premise that outside the port proper, unlike the other ports visited, firefighting tasks are less critical because few occasions would be likely to create a hazard to other vessels, facilities, or populated areas. Some naval assistance is available if needed, but most cases appear to be critical only in terms of search and rescue, rather than in ensuring safety of the port.

The Houston Port and Ship Channel

The Houston Ship Channel and Port of Houston constitute what could be a relatively dangerous port complex, largely because of the 50-mile-long dredged ship channel averaging 40-feet deep and 400-feet wide in restricted portions. The channel connects the Port of Houston and Galveston Harbor across from Port Bolivar. The channel and Port of Houston complex was considered to have potential fire problems because of the relatively restricted waterway, the level of traffic, and the commodities handled, particularly petroleum and petrochemical products. The channel was not considered quite as problematical as, for example, the Delaware River and associated ports, partly because of the relatively shorter response distances involved, partly because of the advantages presumed to be provided by the Vessel Traffic System, partly because a higher percentage of facilities appear to be either modern or modernized, and partly on the assumption that resources for response are more readily available and probably more technically appropriate for fires from the cargoes carried. That response capability appears to be better organized, perhaps because it is heavily industry-oriented and composed of industries with common interests. In addition, even if local, mutual aid resources are inadequate, additional resources and technical assistance are available in a few hours from almost any direction. One exception to a general availability of

response resources is a possible shortage of waterborne firefighting capability. Again, the problem seems less severe than on the Delaware because of less fluctuation in the number of boats that could respond, even if some had to come from offshore locations. A minor advantage for waterborne response in the Channel derives from the low current (2 knots versus 5-12 knots at Philadelphia) and low tidal swing (1 foot versus 6 feet at Philadelphia).

Development of the Port of Houston and many of the service functions of the Port are controlled by the Port of Houston Port Authority of Harris County, Texas. The Port Authority has certain state-delegated powers for safety, firefighting, and navigation control, as well as authority for approving revenue bonds isued through the Port Development Corporation.

Traffic is high, with 5,476 ships calling at the Port in 1980. This number includes 2,135 tankers and 400 container vessels. In 1980, changes in trade from 1979 include an increase of 21% in general cargo, (including a 13% increase in container shipments), an 11% increase in grain shipments, a 30% decrease in crude petroleum imports, and a 10% decrease in shipping of petroleum products. Major products handled include 20.6 million tons of crude petroleum, 12.3 million tons of grain, 3.3 million tons of iron and steel products, almost 2 million tons each of fertilizers and organic chemicals, and more than a million tons

each of iron ore and crude minerals. About 3/4 of a million tons of natural gas liquids are handled.

Total vessel transactions over a six-month period were recently reported to exceed 70,000 movements in the Port and channel, with 70% of the traffic carrying hazardous materials.

The principal marine firefighting resource for the Port and channel are two Port Authority fireboats, the Captain Crotty and Captain Farnsworth. The Crotty is based on the Turning Basin at Manchester Wharves. The Crotty is 75-foot long, single screw, with four engines producing 800 hp. Her top speed is 13 knots, and her four fire pumps deliver 6,000 gpm. The boat carries 3,000 gallons of foam agent and has a 30-foot tower and six monitors. The Crotty was acquired in 1950.

The Farnsworth was acquired in 1974 and is stationed at Barbour's Cut Terminal. The Farnsworth is 80 feet long and has a speed of 15 knots, powered by twin screws and two 1,200 hp engines. Fire equipment includes two 6,000 gpm pumps, 2,000 gallons of foam, 2,000 pounds of dry chemicals, a snorkel boom with 55-foot extension, two 2,000 gpm monitors, and self-protecting spray curtains.

Each boat is manned by 16 Port Authority marine fire fighters to provide 24-hour duty. The boats are financed partly by the Port Authority and partly by harbor use fees.

Specifications have been prepared for acquiring two boats, possibly in 1982. Present recommendations are for two aluminum-hulled boats designed for light draft, quick response. The 50-foot boats will each have two 3,000 gpm, 140 psi pumps and will carry 1,000 gallons of foam concentrate. If both new boats are obtained, the Crotty will be retired. The new boats will be based at the Turning Basin and Barbours Cut Terminal and the Farnsworth will be moved to a point about halfway between. Barbours Cut is the nominal downstream boundary of operations for the Authority's fire boats, although they have responded to Bayport at times.

The Port of Houston has a well-organized mutual aid organization called the Channel Industries Mutual Aid Association (CIMA). Significant specialized firefighting capability (manpower, agents, and equipment) can be assembled from the CIMA participating industries, although the CIMA has no watercraft. However, the Port of Houston almost invariably has both large and small tugs in the vicinity which can and do assist in firefighting. No other municipal fireboats were reported in the vicinity of the channel and Galveston Bay.

Lower Mississippi and the Port of New Orleans

The Captain of the Port of New Orleans has responsibility for over 100 miles of the lower Mississippi River, Lake Ponchartrain, and a complex system of interconnecting

canals and waterways, as well as the Port of New Orleans. The Port and other areas are used quite heavily by large and small merchant ships, barges, and tugs. Over 270,000 vessel transits occur annually in the New Orleans area, one-third of which are tank ships or tank barges. Pleasure craft usage in the Port is moderate, but in areas like Lake Ponchartrain is increasing.

Cargo handling facilities in the Port include grain loading systems, general cargo, container cargo, and flammable liquid transfer terminals. Twenty-two terminals are designated facilities of particular hazard. Facilities range from older wooden structures to modern, fire resistant structures. The Port Safety Officer at New Orleans estimated that 80 percent of all vessels entering or leaving the port contained dangerous cargo.

Vessels available to the Captain of the Port include four 32-foot port safety boats, one 82-foot WPB, two 100foot WLI "C," an LCM and a 53-foot crew boat stationed at Venice. Other vessels may be available through Group New Orleans and District Operations and may include 44-foot MLB's, 82-foot WPB's and medium endurance cutters. Air assistance is available from Air Station New Orleans with HH-52 and HH-3 helicopters and an Albatross patrol plane. Coast Guard participation in firefighting is moderately high, both within the Port and on the river and waterways.

The only dedicated marine firefighting vessels are two fireboats owned by a state agency, the Board of Commissioners for the Port of New Orleans. The _Deluge_ is 138 feet long with 10,000 gpm pumping capacity at 150 psi. Top speed is 15 knots. The boat has a crew of eight and carries 2000 gallons of foam concentrate. The _Deluge_ was built in 1923. The second boat, the _Bourgeoise II_, is 94 feet long with 10,000 gpm pumping capacity and a top speed of 12 knots. This boat also has a crew of eight and carries 1200 gallons of foam concentrate. The _Bourgeoise_ was built in 1942.

The _Deluge_ is manned constantly; the _Bourgeoise_ is manned 12 hours a day. The crew are state civil service employees, rather than members of the New Orleans Fire Department. At least one of the fireboats responds to any fire within the Board's jurisdiction. On occasion, a single boat has been allowed to assist at fires at remote locations on the river.

Other waterborne assistance is formally available at times from the U. S. Army Corps of Engineers and the U. S. Navy. A formal mutual aid agreement has been approved by the State Board of Commissioners for the Port of New Orleans (for Harbor Police and fireboats), the U. S. Navy, the U. S. Army, and the Coast Guard. Emergency notification is through the Harbor Police Central Control Point which in turn notifies the Coast Guard and New Orleans Fire

Department, dispatches the fireboats, and notifies the other parties to the agreement if their services are needed. The Coast Guard boats, fireboats, and New Orleans Fire Department have access to a common radio frequency. Although the fireboats respond, wharf fires are considered the responsibility of the New Orleans Fire Department.

The Coast Guard's general response to a fire call is to send the Ready Boat Crew to see what the situation is. (One 32-foot boat is kept on the river side of the locks; the other 32-footer and all other boats are on the lake side of the locks.) Someone from the COTP office also checks out the scene (often by car or helicopter). Then, if necessary, a larger boat is sent to the site for traffic control and communications. After that, any other available resource is called upon. The COTP does not have a specific firefighting crew; the personnel sent to a fire are those people who are on the ready boat or others on base at the time of the call.

Outside the Port of New Orleans the situation quickly changes. Communications with volunteer fire departments are generally poor. The firemen are poorly trained for marine fires. Response time from the Port of New Orleans can be very long. At times, the volunteer fire departments have put their fire trucks on barges or ferry boats for use in fighting marine fires.

Outside the Port of New Orleans, the Coast Guard was generally considered (by others) to be in charge of marine

firefighting. To some degree, this was also the case within the Port. Small operators (tow boats, etc.) seemed quite willing to help fight fires and help each other. Ships' crews were generally reported to be of no help in fighting shipboard fires.

The Coast Guard personnel were very short on protective clothing, breathing equipment, etc. No turnout coats, boots, gloves, or helmets were available. A few Scott Air Paks were scattered throughout the base. The Port Safety Officer was trying rather hard to get more gear (difficult to do because the equipment could not be justified by saying it was for firefighting since the Coast Guard is not supposed to be a firefighting group).

The main problem areas noted by the Coast Guard personnel were as follows:

1. The assumption, by other persons, that the Coast Guard is in charge of firefighting.
2. Lack of adequate safety equipment.
3. The Port Fire tug crews need more knowledge of ship design so they can find their way around.
4. It is often difficult to find out what cargoes are on board a burning vessel.
5. It takes a long time to get adequate construction drawings of a ship.
6. On large ships, the Master and the Chief Mate are in charge but the Chief Engineer is the man with knowledge of fire pumps, emergency generators, etc.

7. Need better on-site coordination of firefighting.
8. Not all fire departments are on the same radio frequency as the Coast Guard.
9. Very difficult to get from Coast Guard boat to the deck of a ship.
10. Monitor nozzle on 32-footer not capable of reaching ship's deck if ship is light.

The Port of Philadelphia

Because a more extensive discussion of the Port of Philadelphia and the Delaware River and Bay are provided in later sections of this report, only general comments are provided here.

The Captain of the Port's jurisdiction extends from Trenton, NJ, downriver past the ports of Philadelphia, Camden, NJ, and Wilmington, DE to Delaware Bay and along the coast beyond Cape May, NJ, and Cape Henlopen, DE. The major concentrations of port activity are at Wilmington, and extending upriver from Marcus Hook, PA, to northern Philadelphia, and downriver on the New Jersey bank from about the same point through Camden and Gloucester City to Paulsboro. This port is considered to be somewhat more problematic because of the existence of large terminals and refineries surrounded by immediately adjacent residential housing (in the downriver suburbs), large, cluttered refineries, and tank farms, and terminals on the Schuylkill river, and the presence of chemical tank farms and cargo

transfer facilities at Port Richmond near residential areas and within a mile of three hospitals.

Boats and aircraft available to the Captain of the Port at Gloucester City, NJ, base and at Cape May and outlying search and rescue stations are discussed in a later section. Principal resources at the Gloucester Base are two 32-foot port safety boats, one 41-foot UTB, two 65-foot WYTM, and one 157-foot buoy tender.

The major firefighting resource for the Delaware and Schuylkill rivers (including the ports of Philadelphia and Camden) are three Philadelphia fireboats. These vessels normally are allowed to assist at fires on both sides of the river from about Port Richmond upriver to Marcus Hook downriver. In the last three years, operations have been altered, so that boats are dispatched only after confirmation of need by a land company. Response to some very large facility fires and ship fires may not require confirmation.

A very small fireboat (jet boat) is available at Bristol, PA, for fires north of Tacony Palmyra bridge.

Other waterborne resources which are sometimes available include U. S. Navy firefighting tugs from Philadelphia Navy Yard and three oil company tugs with firefighting capability. The availability of these resources is not dependable. Similarly, commercial tugs and towboats are sometimes available, but on an unpredictable basis.

Mutual assistance agreements are generally not formalized along the Delaware River, although there appears to be a strong commitment to mutual assistance among the volunteer fire departments along the river and inland. Some industrial mutual aid occurs, but in an informal fashion. Refineries, chemical plants, and bulk flammable liquid terminals will ordinarily assist neighboring industry or municipalities, but are reported to have resisted aid from municipalities and to be uncooperative with local fire departments when joint training or plant familiarization is suggested.

Facilities handling more general cargo vary from highly fire conscious with good response capability to old, trashy, and careless. One such facility was reported to have had one pump of two feeding a common fire main wired to run backwards since its installation thirty years ago. Fortunately, that pump had never been needed for a fire, since it would have reversed most of the flow from the other pump.

The more problematic areas for the Captain of the Port are considered to be downriver between Paulsboro and Marcus Hook. The Wilmington, DE, Port has no waterborne firefighting capability (with the possible exception of commercial tugs). Any assistance would have to come from Philadelphia or the Coast Guard at Gloucester City. No mention was made of Philadelphia fireboats responding downriver as far as Wilmington.

Although the occurrence of fires downriver from Marcus Hook appears rare, clusters of other types of incidents appear, for example at the upstream and downstream sides of Pea Patch Island near Delaware City, further downriver near Joe Flogger shoal, and nearer the mouth of Delaware Bay around Brandywine Shoal. Although Pea Patch Island is several hours from assistance from Gloucester City, it is in that base's operational area which extends downriver to Ship John Shoal. The other areas mentioned are in the Cape May area of operations, and are twenty to thirty miles from Cape May Station.

What adds somewhat to the questionable status of this port is the likelihood that Philadelphia may not be able to serve the tri-state area forever. Indications of the effect of growing fireboat costs and aging fireboats are apparent in the change in operations affecting dispatch of the boats. The Navy tugs are recently reported to have been moved from the Philadelphia Yard. At the same time, maritime commerce continues to increase, particularly in petrochemicals and more recently in coal. Although a new fireboat has been budgeted and plans are underway to consolidate some Philadelphia emergency response agencies and the Coast Guard COTP base along the Philadelphia shoreline, these changes will have little effect downriver.

A HYPOTHETICAL RANKING OF RISKS

AND OTHER COMMENTS

In part as an exercise for clarifying the types of response that might be useful in the ports visited (without reference to any probability of occurrence) general impressions and judgments based on discussions in the ports; review of three to four years of emergency response information from fire departments and COTP's; and the physical, geographical, and trade characteristics of the ports were incorporated in a relative ranking of risks for the ports. Five categories were chosen for comparison. The results of those judgments are as follows:

Ranking of Risks

A. SHIP FIRE DANGER TO THE PUBLIC

1) Philadelphia
2) Houston
3) New Orleans
4) Los Angeles

B. FACILITY FIRE DANGER TO THE PUBLIC

1) Philadelphia
2) New Orleans
3) Houston
4) Los Angeles

C. LARGE CLASS A FACILITY FIRE POTENTIAL

1) New Orleans

2) Los Angeles

3) Philadelphia

4) Houston

D. MARINA FIRE POTENTIAL

1) Los Angeles

2) New Orleans

3) Philadelphia

4) Houston

E. SMALL BOAT FIRES AT DISTANCE

1) New Orleans

2) Houston

3) Los Angeles

4) Philadelphia

Category A, Ship Fire Danger to the Public, is a judgment of the possibility of firespread or development of other hazard (normally hazardous vapors) as a result of ship fire or accompanying a ship fire (as in a collision/fire incident). Hazards other than fire are not necessarily assumed to be caused only by fire. This judgment necessarily includes some judgment of proximity of segments of the public, but is not limited to residential population. Occupants of other vessels and other facilities are included. Philadelphia was considered to have a higher incidence of proximity of residential and industrial public

and the potential hazard, essentially clustered at Paulsboro, Marcus Hook, the Schulkyll near the Delaware, and Port Richmond. Houston's ranking was more in relation to proximity of facilities and a presumed potential for greater frequency of incidents.

Facility Fire Danger to the Public incorporates the same factors mentioned for ships. Houston was ranked lower than New Orleans essentially on the premise that a significantly better mutual aid system is in place, and that the response capabilities of individual facilities are better. Philadelphia is considered to be weak in both those respects. Los Angeles' waterfront facilities are considered more isolated and better maintained and have support of excellent emergency response systems.

The Large Class A Facility Fire Potential is a judgment based on our internal discussions comparing impressions of the ports. This ranking relates only to potential and not to any level of hazard. It is probably related to a judgment of the number of facilities observed, their age and condition, and sparse information on the general self-help capabilities of such facilities. The distinction between Los Angeles and New Orleans includes some judgment of the likelihood of fairly rapid control of the initial fire. This category has some relevance to a type of firefighting that would be more of a problem for Coast Guard resources, which is reflected particularly in

the top ranking of New Orleans. Coast Guard capabilities are irrelevant in Los Angeles and limited in Philadelphia.

Marina Fire Potential is a judgment related in part to property value (the category was originally titled Marina Fire Problem). It includes some observation of marina layout, which affects both the maximum size boat that could respond and the potential for assistance from land companies. Los Angeles marinas are large, contain much high-value property, are of design that prevents anything but small fireboats or Coast Guard boats from responding, and frequently do not appear very accessible by land units. Philadelphia's marinas for the most part appear to be accessible by either water or land.

Small Boat Fires at a Distance is related to some expected degree of need for Coast Guard response. New Orleans and Houston rankings are related to the use of small boats in the Gulf and on the Mississippi. Los Angeles' problem is believed to be less because of its proximity to open sea, which should act as a limiting factor for distance the boats venture from the port. Los Angeles' ranking also reflects the fact that Coast Guard boats do not have to provide for response in the harbor. Philadelphia's ranking reflects mostly the search and rescue capabilities available to the Captain of the Ports, particularly in summer when additional SAR stations are operating. Our general impression is that small boats, particularly recreational boats, are not in as prevalent use in the Philadelphia area.

In each of the ports, both traffic and trade are increasing. While these factors undoubtedly increase the frequency of opportunity for incidents to occur, they should not affect the sizes of fires that can occur.

The "risks" ranked here are actually of two types. The marina and small boat fire problem affects the Captain of the Port as a matter of frequency of response. In some ports, the small boats of the Coast Guard, particularly the 32-foot boat, may be the best resource for limiting losses in marinas. Small boat fires at a distance are mostly a problem of rescue, and if beyond aid of nearby vessels, are almost solely a problem for the Coast Guard. Success in saving substantial value of the burning small boat through firefighting efforts has been historically very low. Altering that pattern is improbable because of response time. Consequently, dispatch of the nearest and fastest response boat is more important than selection of a boat which might be able to extinguish the fire.

The other three "risks" discussed here, although expressed as a public danger, are also related to the larger problem of overall safety of the port and effect on its operations.

Other Miscellaneous Comments on Selected Ports

Some general items of information were obtained in discussions in the various ports, practically all of which was the opinion of local Coast Guard personnel. Two types

of these miscellaneous comments are presented here. The first brief comments are in a sense related to the rankings just discussed, because they have some characteristics of rankings.

One of the discussion subjects was the perceived level of firefighting activity by Coast Guard boats of the Captains of the Ports. Incidents involving boats dispatched by other commands or command levels would not be included in these judgments. No distinction in response times (time from notification until boat was on scene) was discernable from port to port. In the majority of cases, response time ranged from about 15 minutes to two hours. The average response time was 25 to 30 minutes. A later review of a selection of radio logs and situation reports and secondary sources such as accident or incident reports supported these estimates.

The level of firefighting activity, defined as actual application of some agent on the fire but without reference to the length of time involved, did vary from port to port. Note that this is the perceived level of activity when a fire occurs, rather than a measure of the total number of responses. Such activity was reported as "never" in Los Angeles, although obviously, outside the harbors, some activity must have occurred. All the other ports reported participating "frequently." Our estimate, without specific reference to data, is that Houston participates at

about 50 percent of occurrences, New Orleans at 55 to 60 percent, and Philadelphia at about 35 to 40 percent.

Coast Guard participation in mutual aid and the nature of that participation was discussed. In Los Angeles, mutual aid is provided for by state statute, relieving the necessity of formal agreements. In practice, mutual aid is by informal agreement or informal common consent. The Coast Guard stays on the perimeter of that informal aid structure and responds very rarely. The Coast Guard is rarely requested to assist. Philadelphia and other Delaware River resources also operate on an informal basis. In this area, however, the Coast Guard does participate and is sometimes requested to assist. Both Houston and New Orleans have formal mutual aid arrangements. Houston's organization, the Channel Industry Mutual Aid Association, includes the Port Authority, Coast Guard, and many industrial firms as formal members. The New Orleans agreement we have seen includes only the Captain of the Port, the Board of Commissioners of the Port of New Orleans, the U. S. Navy, and the U. S. Army Corps of Engineers.

A question which has some relevance to Coast Guard firefighting policy is how frequently and at what level the Coast Guard assumes command or active coordination of firefighting efforts. This again is a question addressed at the "perceived level," and the response has reference to large fires in Philadelphia and Los Angeles and at New

Orleans to both large fires and fires on the Mississippi at outlying communities. At Los Angeles, the Coast Guard never assumes command of or coordinates the response, and are rarely deferred to for advice. When advice is sought, it is usually with regard to fire in an unusual commodity or unusual circumstances such as a question of stability of the burning vessel.

At New Orleans, the Coast Guard perceives their role in command as significant. In the vicinity of the port, there is apparently a tendency for fireboat commanders to depend on Coast Guard direction. Local COTP personnel believed that tendency was because of limited capability of the state-operated fireboat commanders. The tendency may occur instead because the fireboats are not part of the New Orleans Fire Department. Lacking that immediate relationship, the fireboats may need an intermediary to provide coordination between them and the Fire Department. In outlying areas, Coast Guard coordination and command is almost necessary, because local resources lack equipment and experience for ship firefighting.

At Philadelphia, Captain of the Port personnel assume responsibility "if necessary." Because the Philadelphia Fire Department fireboats engage in almost all instances of firefighting requiring a waterborne response, decisions by the Coast Guard are "necessary" only in a sort of on-and-off manner during the course of a large fire.

Sometimes decisions and direction are necessary because no one else takes the responsibility. Sometimes control passes back and forth between Coast Guard and the fireboats. Volunteer departments along the river rarely or never want to direct waterborne operations. It is probable that direction of commercial tugs is always a Coast Guard task. In some respects, the fireboats seem to ignore the presence and activity of boats which have responded. At Houston, direction appears to be a joint function of Coast Guard and fireboats. Each appears to respect the capabilities of the other. On the surface, at least, the Houston mutual aid organization appears to be better organized and more cognizant of the capabilities of the various members.

The differences in relationship between Coast Guard and fireboats in Houston, New Orleans, and Philadelphia appear to be in part a result of attitudes. At New Orleans, Coast Guard attitude seems to be, "We may not know what we're doing, but they know even less." At Philadelphia, the fireboat commanders' attitude seems to be, "We know exactly what we're doing, and anyone else can do what they like, as long as they stay out of our way."

Other Comments

A number of comments were related to equipment and other deficiencies perceived by COTP boat crews and other port safety personnel.

1. Boats are too small to get water to the decks of ships. Taking hose aboard a ship is difficult because of ship height. Higher speed would be especially helpful in getting to a fire before it is completely out of hand. Some method of preventing debris (hawsers, cables) from fouling the screw is needed. Main engines should not drive pumps, because of maneuverability and stationkeeping problems.

2. Pumps are too small; can't get enough pressure. When pumps are powered by main engines, capacity and pressure are often not available, and power transfer is troublesome. Portable pumps are not very reliable for more than a short time. Not enough portable pumps are available to make up for the number that are inoperable. A suction to sea chest should be available for the portable pumps to reduce deck clutter and reduce problems from debris.

3. Boats do not carry enough foam concentrate. All boats should be provided with in-line proportioners. Using agent from five-gallon cans can be a problem; an installed tank would be a big improvement.

4. Some of the monitors are old and not very good. Nozzles sometimes don't work because of dirt or corrosion. Not enough hose is available. Where less than a fifty-foot length of hose is needed, for example to connect monitor to outlet, hose has to be strung all over the deck, because shorter lengths are not issued, and we have no way of making up our own or of having them made up. Monitors should all

be fed from piped systems, rather than jury-rigged hoses. Suction hoses get beat-up, and sometimes are too old to be reliable. Some boats don't have good nozzles available. International connections are not always available.

5. Personal gear could be improved. Turnout coats and firefighter boots would be better than issue clothing for firefighting in wintertime. Insufficient supply of OBA masks and canisters. Air bottle breathing apparatus would be better. Using air bottles might be a problem because of refills. Nomex® suits would let us move in closer to the fire.

DEFINITION OF GENERAL FIRE SIZES

For the purposes of discussion in this report, it has been necessary to characterize fires in terms of size, with the intent that the general reference of fire size is related to estimated difficulty of control or extinguishment. It is believed to be useful to provide examples of typical fire sizes to clarify the term. The examples should be considered as occurring without other serious complicating conditions such as adverse weather, high seas, adverse tidal conditions, or exceptionally toxic vapors or combustion products.

Since many accompanying conditions can seriously affect the capability of a given response effort to control the fire, such adverse conditions should be assumed to move a given fire size characterization towards the next larger size category. Similarly, a smaller or otherwise less effective response effort working a given fire size would in effect be concerned with a "larger" fire size. Thus in a boarding fire situation, a fireboat carrying 22,000 gpm pumping capacity, 1,000 gallons of foam concentrate, and a crew of eight is in effect responding to a smaller fire than the same fire faced by three USCG 40-foot utility boats, each with 250 gpm pumping capacity, 40 gallons of foam concentrate, and a 4-man crew. A given ship fire size also seems to be affected by where it occurs, so that, for

example, a given fire in a vessel tied at dock is effectively smaller than the same fire in a vessel in anchorage, and both are smaller than the same fire in a ship underway or hove-to in open water. Part of the difference is the effect of response time, but most is related to the problems of boarding men and equipment.

Fire Sizes at Dock

Small: Fires in the very small to small range should be controllable by the ship's crew. However, due to lack of experience, equipment problems, or delay, the crew may not extinguish the fire, and Coast Guard or other outside aid may work fires still small. The examples provided at the end of "Fire Fighting Manual for Tank Vessels," CG-329, are all in the very small to small range, with the exception of the supertanker collision fire described after Case 1 of "Cargo Tank Fires." Typical small ship fires would include a fire from any of the following sources: overheated deep-fat fryer; galley exhaust vent; electrical insulation in electrical panel; fire in paint locker or boatswains stores; auxiliary internal combustion engine fire; cargo tank vent stack fire; or a single container in a hold. Fire in 1 or 2 containers on deck of a loaded container ship is considered small because of relatively better access and visibility. Engine room small spill fires or lagging fires are considered small as long as the engine room can be entered. Other examples of small

fires include fire involving a single aircraft on open deck or fire from a moderate (40-ft diameter) spill on deck.

A specific example of a small shoreside fire occurred at Marcus Hook, PA, in November 1974. The crew of the 65-foot WYTL Catenary while on patrol observed fire on and around elevated, 12-inch cargo transfer hoses at an oil terminal dock. The 4-man crew of the Catenary, constrained to attack from downwind, maneuvered the bow of their vessel against the dock and attacked with two 1 1/2-inch lines, solid-stream with foam. The nozzlemen were protected by high-velocity fog. After 17 minutes, the Catenary received assistance from two land companies (fire was now contained to 30 foot wide, 20 foot inland pool). The surface fire was extinguished 34 minutes after Catenary's arrival. Fire fighting had been complicated by dense smoke and possible occasional flame blowing across the men on the bow of the Catenary, by the necessity of using propulsion power for stationkeeping (which reduced the power available for the firepump), and by the fire base being three dimensional because of fire in the elevated transfer hose and dripping fluids.

As a matter of judgment, this fire appears to be the maximum (or perhaps slightly more than the maximum) fire that could be controlled by a single USCG vessel of this class or capacity. Control was probably marginal, and it is doubtful that any foam agent was unused after the first 20

to 23 minutes. As a matter of speculation, foam was probably being produced at less than 60 gpm and used intermittently. The second 1 1/2-inch nozzle was probably used for high-velocity fog and some solid-stream water, again at less than 60 gpm when flowing. Pressure achieved was probably about 65 psi which would have provided about 60-foot projection of a straight water stream.

The 65-foot WYTL has an installed pump driven by power takeoff from the main propulsion engine. The pump is rated at 300 gpm at 100 psi. Some of the effect of shared use of the main engine may have been demonstrated at the fire just discussed. However, a demonstration of solid stream quality from this vessel's demountable monitor some months after this fire was about as described above--a good stream for about 65 feet.

<u>Moderate</u>: Moderate fires may be controllable by knowledgeable crews with appropriate equipment. Typical fires classed as moderate include galley fire in deep-fat fryer with secondary fire in Class A ceiling or wall materials; fire in cabin space with fire in overheads; engine room-pressured fuel spill fire with 20-foot diameter equivalent pool fire or fire in sumps requiring evacuation of engine room; liquid fuel spill fire extending to deck below original spill; cargo or day tank fire where openings to tank exist; fire involving single aircraft in hanger or other enclosed space; hold fire from ruptured drum where

spill fire surrounds ten or more drums of flammable liquid; free-burning fire in a single hold involving containers or packaged Class A combustibles; and fire in two or more cabins of large passenger vessels.

An example of a moderate class fire occurred on May 4, 1972, to the gasoline tanker M/V Venus at anchor in the St. Lawrence River. During tank-washing and gas-freeing operations, vapors were ignited in the lower-forward crew quarters area. Two consecutive explosions occurred in the No. 1 tanks. Fires in the tanks were subsequently controlled with foam from an installed foam system monitor. The installed system includes a 200-gallon 3% foam concentrate tank, 4-inch mains, monitors and auxiliary foam hose stations forward, midship, and aft, and a 200-gpm pump set at 125 psi. The deck fire main system has 9 hydrant stations with 1 1/2-inch lined hose. All foam concentrate was eventually used and water from the forward and midship foam monitors was used to continue cooling. Fires in a deck gear locker in the forward lower crew deck hall were controlled with a 1 1/2-inch hose connected to the foam system main. Assistance from a salvage tug arrived one hour and 40 minutes after the initial explosion. The fires were essentially out. A second tug arrived four and one-half hours after the explosion and replenished the foam concentrate supply. The first Coast Guard boat was dispatched 4 hours after the explosion and arrived 10 hours after the explosion.

The M/V Venus fire fighting was complicated by several factors. The Venus was anchored because of dense fog. Only a well-equipped salvage tug was able to respond to assist in the fog: three other vessels underway to assist became fogbound. One foam hose from the forward auxiliary foam station burst when pressure was applied. The hose used to fight the fire in the crew quarters area burst in two places just as the fire was controlled. The master of the Venus was killed by debris thrown by the second explosion. Four crew men were injured, three of whom participated in the firefighting.

A second example of a moderate class fire occurred in a hold of the freighter M/V Thorstream on June 2, 1967. Drums of calcium hypochlorite being lowered into a deep tank (hold) by sling and pallet fell from the pallet at main deck level to temporary wooden flooring at the bottom of the deep tank. At least one falling drum ruptured, the third struck the second, and intense fire ensued. The crew directed two hose streams into the hold. Fifteen minutes after ignition, the first municipal fire department company arrived and immediately took over the firefighting. A second alarm was turned in ten minutes after the first company arrived. A team of four fire fighters wearing SCBA (self-contained breathing apparatus) descended to the tween deck. Two then descended into the deep tank and attempted to use a 2 1/2

inch fire hose but had problems handling the hose slack and in opening the nozzle. One man noticed he was low on air and returned to the tween deck. The remaining man finally got the nozzle open and extinguished the fire, most of which was in a pile of dunnage. The fire was extinguished 53 minutes after it started.

The most serious problem at this fire was dense smoke from the burning chemical and the dunnage. Although there were SCBA's (air packs) on the ship, only one was used, and that by a longshoreman who descended to the tween deck and rescued one longshoreman who had been in an adjacent deep tank. Four longshoremen in the fire-involved (port) deep tank died almost immediately in the intense fire. Although the crew could have attacked the fire in the hold using air packs, they did not. Although the municipal fire department ultimately had seven pumpers and six ladder trucks on scene, apparently only the single man with the 2 1/2-inch hose actually attacked and extinguished the fire. The coast Guard COTP was notified seventeen minutes after the fire started; the information was relayed to the base four minutes later. Two utility boats arrived at the scene about twenty minutes later. An inspection party and fire party were dispatched by land and arrived thirty and twenty minutes, respectively, after notification. No Coast Guard assistance was required.

Large: Fires which are characterized as large would include flaming fire in two or more holds, particularly on vessels without fixed firefighting systems for holds; one ruptured cargo tank with flammable spill overside; engine room fire when intense and large fire prevents reentry; fire in cabin space involving two or more spaces with fire spreading in overhead; container vessel fire in ten or more containers with no separation from surrounding containers; and fire in bridge requiring evacuation of bridge.

A very large fire at dock was the explosion of the Sansinea on December 17, 1976. A typical large fire in a tanker underway was the fire on the Edgar M. Queeny after it backed away from the ramming of the Corinthos. These fires are discussed extensively elsewhere in this report.

A typical large shoreside facility fire occurred on the Houston Ship Channel on September 21, 1975 in a plastics manufacturing plant. The fire began in a 35 x 700-ft extruder building. Buildings #1 (40 x 800 ft) and #3 (30 x 600 ft) on either side were also eventually destroyed. All buildings were of metal construction on concrete slab. The buildings occupied about 1.5 acres in area, and at times, as much as an acre of burning material was involved. A vessel at the facility adjacent to the plastics plant was cut loose of moorings and towed away by commercial tugs within 25 minutes of discovery of the fire. The ship damage consisted of blistered paint, cracked glass portholes, melted safety

net, damaged life rings, and weakened manila boat falls and man ropes.

This fire was fought unsuccessfully from land by two municipal fire departments and from waterside by two port authority fireboats and three 30-foot Coast Guard UTM's.

The fire was reported extinguished after ten and one-half hours. The land company pumpers, Coast Guard boats and one fireboat were secured after 16 hours. About an hour and a half later, the fireboat on scene requested a 30-foot UTM to extinguish an area under pilings that had reflashed. This fire was extinguished after 50 minutes. The fireboat and 30-foot boat remained as reflash watch for another ten and one-half hours.

Problems at this fire included the laid-up ship whose moorings had to be cut; one fireboat fouled a screw in a mooring line in the water and had to be aided in maneuvering by one 30-foot UTM for seven hours; and at five and one-half hours, eight hours, and twelve hours, a Coast Guard boat had to withdraw and return to base to replace inoperative P-250 pumps.

Although this fire was only contained to the plant area and not extinguished until the entire plant was destroyed, it is classed as a large rather than catastrophic fire because there was no extreme danger of wider firespread or explosion. Undoubtedly, a major factor against successful extinguishment was the 600- to 700-foot extension

of the buildings perpendicular to the waterfront, which put much of the fire far out of range of the boat streams as well as making access difficult for the land companies.

Other large fires include the fire originating with Tank Barge MOS 106 on the Mississippi, May 12, 1969, which eventually involved scattered fires in five vessels, a loading facility, and a grain elevator, with the burning MOS 106 lodged against a railroad bridge span.

The *Key Largo* fire on the Mississippi near New Orleans September 2, 1975, was a small hold fire in dangerous cargo (calcium carbide drums) which progressed to a large fire, resulting in total loss of ship and cargo. The fire in the hold apparently originated from spilled calcium carbide and was attacked from the main deck with three 2 1/2-inch hose streams. After some time, the vessel was intentionally grounded to prevent sinking in the channel due to fire water in the hold. Two towboats then began to assist the firefighting, and at one time, eight hose streams were being played down the hatch into the burning hold. About three hours after the fire was discovered, COTP personnel advised the master of the nature of the 680 drums of cargo in the burning hold and of the imminent danger of explosion if the carbide contacted water. The master, pilot, towboat crews, and all hands abandoned the ship. The fire thereafter burned out of control for about three weeks.

If the *Key Largo* fire had been attacked initially with a dry chemical suitable for fires in calcium carbide, the fire could probably have been controlled and extinguished in its early stages, and therefore, while still a very small fire.

Other examples of very large fires which will be cited were of such size or such intensity that sometimes a minor change in circumstances would have caused their classification in this discussion to the catastrophic rather than the very large. The *Sansinea* explosion and fire was in our estimate a similar borderline case, with two prevailing circumstances causing its assignment to the very large category. These circumstances were that, notwithstanding the distant damage from explosions, the limited cargo and prevailing harbor conditions limited the potential for more extensive spread of fire. The firefighting forces at the *Sansinea* were extensive. At some time, 240 municipal firefighters may have been in action in 10 task forces, 7 single-engine companies, 5 fireboats, and manning 5 foam apparatus and 2 tankers. A few commercial craft may have participated. Coast Guard response included one large cutter (WMEC), four 82-foot cutters, one 40-foot and one 41-foot UTB, two smaller boats, and 2 HH 52-A helicopters. Only the 82-foot cutters participated extensively in firefighting.